NAVAL POSTGRADUATE SCHOOL

RESEARCH

Volume 10, Number 1 *February 2000*

NPS ESTABLISHES A CENTER FOR RECRUITING INNOVATION: TWENTY YEARS IN THE MAKING

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Background

In the early 1980s, Professor Richard Elster, Academic Associate for the Manpower, Personnel, and Training Analysis Curriculum in NPS' Department of Administrative Sciences, had a vision of creating a new research center at NPS. The Center would bring together some of the nation's most prominent analysts in military manpower, including those already at NPS, and help the military services to solve their seemingly intractable problems in recruiting and retaining high-quality members. Indeed, in 1979, America's All-Volunteer Force (AVF) was on the brink of disaster: recruiters were missing their goals; personnel attrition seemed uncontrollable; troop morale waned along with public perceptions of the military; reports of disciplinary problems, drug use, and substandard performance circulated widely; and there were repeated reports that the force was "hollow."

Just a few years earlier, Congress had decided to take away GI Bill benefits for new recruits—at a time when military pay was eroding, the civilian job market for young men was improving, and the "enlistment propensity" of prospective volunteers was decreasing sharply. The news media were filled with grim accounts of recruiting fraud and the hardships of service life. Even Richard Nixon, the so-called "father" of the modern AVF, lost faith in the volunteer military's ability to maintain national security. "I had considered the end of the draft in 1973 to be one of the major achievements of my administration," Nixon wrote in *The Real War*. "Now, seven years later, I have reluctantly concluded that we should reintroduce the draft."

Professor Elster's efforts to build a new research center were boosted in 1982 with the hiring of two adjunct research professors—including Mark Eitelberg, who brought with him promises of long-term sponsorship by the Office of the Secretary of Defense. Before long, NPS attracted a host of research sponsors that included the Navy Personnel Research and Development Center, U.S. Army Recruiting Command, DoD's Directorate for Personnel Security Policy, the Military Entrance

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is published by the Director of Research Administration in accordance with NAVSO P-35. Views and opinions expressed are not necessarily those of the Department of the Navy. Comments/inquiries can be addressed via email to research@nps.navy.mil.

NAVAL POSTGRADUATE SCHOOL

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
FEB 2000		-

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Naval Postgraduate School Research. Volume 10, Number 1, February 2000	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**44**	

CENTER FOR RECRUITING INNOVATION, *continued from page 1*

Processing Command, the Office of the Chief of Naval Operations, and the Defense Manpower Data Center, among others.

The Pendulum Swings Yet Again

Military recruiting generally flourished during the latter half of the 1980s and for the early years of the next decade. After the conclusion of the Gulf War, however, the military's reduction-in-force gained momentum, and research appeared to focus more on finding ways to "fire" than hire. The military's public profile diminished considerably in the aftermath of the Gulf War, even though the demands placed upon the force seemed to escalate throughout the world. The military's own recruiting market surveys revealed that young people's interest in applying for enlistment—called "propensity"—was dropping quickly. Some analysts claimed that this declining interest reflected falling levels of military experience among the parents of prospective recruits. Others pointed to the erosion of personnel pay and benefits, or the relatively low morale of a force that was continually being pushed to do more with less. Most analysts of recruiting trends would admit that a combination of events and circumstances operated to the detriment of attracting qualified applicants—yet most would also say that two factors were largely responsible. First and foremost was the nation's strong economy; and, added to this, was military recruiting's failure to understand and reach its primary market of young men and women. The old ways of sending forth the message of recruiting were falling flat. With the benefit of once-high unemployment rates, federal cutbacks in financial aid for college-bound youth, and weak competition from civilian employers of entry-level workers, no one seemed to notice that the old ways of military recruit-

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About the CENTER DIRECTOR

Mark Eitelberg is a Professor of Public Policy in the Department of Systems Management and an internationally recognized authority on military manpower policy and one of America's principal scholars of the All-Volunteer Force (AVF). He has been studying the AVF since 1976 and has directed approximately 35 research projects for OSD and U.S. Defense agencies. In addition, he teaches policy analysis and military sociology/psychology in the Manpower Systems Analysis (MSA) Curriculum at NPS and in the Leadership Development and Education Program at the U.S. Naval Academy. Dr. Eitelberg is the author or co-author of over 100 publications and professional papers and he has served as an advisor on more than 130 Master's theses. During the past several years, his research and writing have focused on issues related to civil-military relations and population participation in the American military.

Mark Eitelberg

Dr. Eitelberg has been a consultant with several government agencies, commissions, and private organizations—including the Brookings Institution, the RAND Corporation, the Atlantic Council of the United States, and the National Research Council of the National Academy of Sciences—and he continues to be an active participant in seminars, panels, conferences, and working groups devoted to the study of military manpower policy and national security. He is a Regional Director of the Inter-University Seminar on Armed Forces and Society (IUS), an "invisible college" for Fellows from over 50 countries. He has been Editor of *Armed Forces & Society*, the official journal of the IUS and a leading publication in its field, since January 1998.

CENTER FOR RECRUITING INNOVATION, *continued from page 2*

ing were becoming ineffective for a new generation of young Americans. It took some very dramatic failures to bring this understanding to full light.

The first such failure occurred at the end of fiscal year 1998, when the Navy experienced a shortfall of nearly 7,000 recruits and the Army missed its accession goal by 776 persons. These shortfalls—twelve percent of goal in the Navy's case—did not escape the watchful eyes of the press, such as *US News & World Report*, which observed in March of 1999: "Where have all the young men gone? Certainly not for soldiers every one—and that suddenly is a major problem for the leaders of the Army, Navy, and Air Force, who worry that their personnel woes may run far deeper than competition from a hot economy and a vibrant civilian job market." The real problem, several observers suggested, is that the military is no longer "relevant" to the lives of young people. Today's kids have become "generationally disconnected" from the military; and the ways of "re-connecting" them rely mainly on methods and messages that haven't changed significantly in at least thirty or forty years.

Fiscal year 1999 witnessed improvement for Navy recruiting, but the service still struggled to achieve its year-end goal. The Army was also able to attain its recruiting goal, but only in the "eleventh hour," and by offering large bonuses and other enhanced incentives. It was still clear to all that recruiting difficulties would persist—as the Air Force stumbled and fell short of its goal for the first time since 1979—and that no short-term solution was at hand.

Over the past several decades, the armed services have relied heavily upon their personnel research laboratories to help reverse the inevitable downturns in recruiting. Yet, for various reasons, these personnel research laboratories—the Navy Personnel Research and Development Center, the Air Force's Armstrong Facility, and the Army Research Institute for the Behavioral and Social Sciences—have been downsized and, in two instances, reorganized into near-oblivion. This has left a large gap in the military's in-house capability to conduct manpower, personnel, and training research.

What better time—that is, one of expanding problems with a diminished capacity for problem-solving—to establish a defense-wide research center devoted to innovation?

An Idea is Born

In the summer of 1998, LCDR Nicholas R. Dodge, USN, approached Mark Eitelberg, Professor of Public Policy in the Department of Systems Management, with an idea for a Master's thesis. Could the Navy's reach into the "Gen-Y" market of potential recruits be strengthened if Navy recruiting took greater advantage of existing technology on the Internet? Indeed, would it be possible to create a sort of "virtual recruiter" on the Internet—that is, a site where young people could not only learn about Navy job opportunities, but also pre-qualify for service and accomplish most of enlistment processing? LCDR Dodge proceeded to explore the development of an "Online Recruiting Station" (or ORS) with research support from Commander, Navy Recruiting Command (CNRC). His research culminated in the construction of an ORS "mock-up" that was tested with a focus group of high school students from Monterey County. The results of focus-group testing confirmed that an ORS would likely appeal to "Gen-Ys" for a variety of reasons: the students felt very comfortable with the Internet format, which allowed them to explore Navy opportunities in anonymity, in their own home or in school, on their own time, and at their own speed; they didn't have to deal directly with recruiters, which they described as irritating, less-than-truthful, insincere, and interested only in closing a sale; and the students were attracted to visual and audio stimuli of the multimedia message as well as to the prospect of a challenging, Internet-based game built around Navy themes. The focus group likewise agreed that the best source of accurate information on Navy jobs would come from sailors serving in those jobs—perhaps through the mechanism of an Internet chat room—rather than through a Navy recruiter.

LCDR Dodge was chosen by the Manpower Systems Analysis (MSA) faculty to present his research findings at "Thesis Day," a briefing by selected MSA students before the Chief of Naval Personnel and other senior leaders from the Navy and Marine Corps in Washington, D.C. Around the same time, Professor Eitelberg proposed to the Directorate of Accession Policy (in the Office of the Secretary of Defense (OSD)) that a prototype of ORS be developed and evaluated for possible future application by the Department of Defense. Professor Eitelberg was later joined in this effort by Associate Professor Magdi Kamel, Information Systems Academic Group. In May 1999, a meeting was held in the Directorate of Accession Policy to discuss the details of the proposed project. The meeting was attended by VADM Patricia Tracey, USN, (Deputy Assistant Secretary of

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FEATURED PROJECT

MARINE KC130 REQUIREMENTS STUDY

Associate Professor William R. Gates, Department of Systems Management
Associate Professor Young Kwon, Department of Mechanical Engineering
LCDR Timothy Anderson, USN, Department of Operations Research
Professor Alan Washburn, Department of Operations Research

The United States Marine Corps (USMC) currently operates 36 F and 14 R series KC130 aircraft, a total of 50 aging aircraft. The USMC is considering retiring them in favor of new J series aircraft, as well as possibly purchasing additional new aircraft. The first part of this article determines the economic retirement date for each of the current aircraft. The latter part estimates USMC requirements for KC130 tankers in the year 2015.

Economic Retirement Date

The immediate question for the F/R series is whether to spend several million dollars per aircraft to modernize the avionics, a modernization that is required by year 2005 if the aircraft are to keep flying. This decision must be made in the face of substantial uncertainty about the structural lifetime remaining in the airframe, the principal concerns being corrosion and metal fatigue. The aircraft have shown few signs of widespread fatigue damage (WFD), but are of an age where WFD should be expected in the unpredictable but not too distant future. The avionics modernization is therefore a gamble. This analysis assesses whether the gamble is a good one.

Most Navy aircraft are managed to ensure that a particular statistic (FLE - "fatigue life expended") remains smaller than 100%. When the FLE for a particular structure approaches 100%, it is typically retired or undergoes a Service Life

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About the INVESTIGATORS

William R. Gates is an Associate Professor of Economics in the Department of Systems Management. He received his B.A. in Economics from the University of California, San Diego and his Ph.D. in Economics from Yale University. He joined the Naval Postgraduate School in 1988. Prior to joining NPS, Dr. Gates worked for nine years as a Senior Economist at NASA's Jet Propulsion Laboratory.

William R. Gates

Dr. Gates' teaching and research interests include applied microeconomics, defense policy analysis, the economics of defense alliances and cost-benefit analysis. Dr. Gates received the 1999 RADM John Jay Schieffelin Award for Teaching Excellence.

Young W. Kwon is an Associate Professor in the Department of Mechanical Engineering. He completed his undergraduate studies at Seoul National University and received his Ph.D. in Mechanical Engineering from Rice University. Prior to joining NPS in 1985, Dr. Kwon had been on the faculty of the University of Missouri-Rolla and also worked as a Senior Engineer at Oil Technology Services, Inc.

Young W. Kwon

Dr. Kwon's teaching and research interests are in the areas of computational mechanics with modeling and simulation, solid and structural mechanics, composite materials, damage and fracture mechanics, fluid-structure interaction, and biomechanics. A paper co-authored with M. DeMaio and D. Adkison, et al, "Continuous Motion Kinematics in the Loaded Human Cadaveric Knee: The Effect of Constraint, Axis, and Cruciate Transection and the Determination of the Instant Center of Motion," won the Excellence in Research Award at the 23rd Annual Meeting of the American Ortho-

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MARINE KC130 REQUIREMENTS STUDY, *continued from page 4*

Extension Program (SLEP), where the part is renewed. The F/R fleet is currently approaching or even exceeding 100% FLE, but, combined with the corresponding avionics upgrade cost, the required SLEP is expensive enough to make retention unattractive compared to buying new aircraft. Lockheed Martin Aeronautical Systems Corporation (LMAS) and NAVAIR showed this in a recent joint Life Cycle Costing study, hereafter referred to as the LCC. In this analysis we study the possibility of upgrading the avionics, but not performing the SLEP.

Measuring FLE is particularly important to this analysis. LMAS has performed fatigue tests on a C130 wing (LMAS, 1995), basically stressing the wing repeatedly in a long experiment (several years) until various parts cracked. Because the wing is the principal structural concern in a new C130, this experiment, along with engineering judgement based on similar experiments, provides a baseline for expectations about lifetime. Real aircraft are not operated under exactly the loads that occurred in that experiment, but there is a theory that makes the experimental results still relevant. This is the Palmgren-Miner rule (Birnbaum and Saunders (1968), Zahavi (1996), Hoffman and Hoffman (1998) that permits a variety of cyclic loadings to accumulate to a sum C that predicts cracking when the sum reaches approximately 1.0. Given the loading associated with a particular flight profile, one can calculate the increment for the sum. The Navy defines FLE to be 2C, so that cracking is to be expected when FLE=2 or 200%. To retire an aircraft at FLE=1 is therefore to retire it well before cracking is expected. The safety factor of 2 is built into the formula because of the notorious unreliability of C in predicting failure. Zahavi gives the interval [.7, 2.2] for the typical range of C at failure, but notes that failures have occurred

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INVESTIGATORS, *continued from page 4*

pedic Society of Sports Medicine. Dr. Kwon is a past recipient of the Menneken Faculty Award for Outstanding Research and is a Fellow of the American Society for Mechanical Engineers.

LCDR Timothy P. Anderson

LCDR Timothy P. Anderson, USN, is a Military Instructor in the Department of Operations Research. He received his B.S. from the University of Michigan and completed his M.S. in Operations Research at the Naval Postgraduate School in 1994. Prior to duty at NPS, LCDR Anderson served as an Operations Research Analyst at the Naval Center for Cost Analysis, a staff officer at the Fleet Training Center-San Diego, and division officer aboard the USS David R. Ray (DD-971).

LCDR Anderson's teaching and research interests are in the areas of military operations research and cost analysis.

He is a member of the Military Operations Research Society, the Institute for Operations Research and Management Sciences, and the Society for Cost Estimating and Analysis.

Alan R. Washburn

Alan R. Washburn is a Professor in the Department of Operations Research. He received his B.S., M.S., and Ph.D. in Electrical Engineering from Carnegie-Mellon University. He joined the Naval Postgraduate School as an Assistant Professor of Operations Research in 1970, following five years with the Boeing Company. He has served as Chair of the Operations Research Department as well as Associate Dean of Faculty.

Dr. Washburn's teaching and research interests are in the areas of applied probability, search and detection, optimization and combat models. He has served as advisor on 67 master's theses and two Ph.D. dissertations.

Dr. Washburn is a member of the Institute for Operations Research and the Management Sciences.

STATE-OF-THE-ART CONCEPTS IN LOGISTICS AND TRANSPORTATION MANAGEMENT SERVE AS FOUNDATION OF TWO NPS CURRICULA

The Department of Systems Management is the largest academic department at the Naval Postgraduate School with approximately 60 full-time faculty. At any given time, there are over 300 students enrolled in Systems Management resident graduate education programs. Nine curricula are supported by the Department.

Transportation Logistics Management and Transportation Management are highlighted in this edition of *NPS Research*. Students enrolled in these curricula work towards a Masters of Science in Management. The primary mission of these curricula is to educate military officers and DoD civilians in state-of-the-art concepts of logistics and transportation management. Emphasis is placed on understanding both military and non-military applications, so that students will be prepared to perform effectively in a military environment and interact efficiently with civilian contractors and suppliers.

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Transportation Logistics Management is an interdisciplinary program that integrates mathematics, accounting, economics, behavioral science, management theory, operations/systems analysis, and a subspecialty concentration into an understanding of the process by which the defense mission is accomplished. The program is designed to provide the officer with fundamental interdisciplinary techniques of quantitative problem-solving methods, behavioral and management science, economic analysis, and financial management. The officer is provided with a Navy/Defense Systems-oriented graduate management education with the specific function skills required to effectively manage in this subspecialty area. The sponsor of this curriculum is the Navy Supply Systems Command.

Transportation Management is designed to prepare officers for logistics system positions, emphasizing worldwide transportation aspects. Graduate logistics courses cover topics such as the transportation system within CONUS, warehouse siting, materials management, production management, inventory management (both defense and private sector), materials handling, purchasing and physical distribution. Students take additional courses in transportation in the private sector and military transportation in support of contingencies, as well as, options in corporate financial management, production management, or logistics engineering. The curriculum sponsor is the Navy Military Sealift Command.

Research supports both the students educational program and DoD sponsors; two such projects are described below. NPS carries out research on the management of DoD transportation systems through its multidisciplinary expertise in fields such as acquisition, project and contract management, financial management, organization and strategy, information systems, and logistics. Current research includes reviews for major DoD programs such as sealift and airlift, evaluation of information technologies used in transportation and logistics, and analyses of financial systems used in the movement of personnel and material.

Analysis and Evaluation of the Korean Flag Shipping (KFS) Program Using Modeling and Simulation

According to an agreement between the U.S. and the Korean governments through the Korean Flag Shipping (KFS) Program, Korean registered merchant vessels could be called upon to assist the U.S. Navy's Military Sealift Command (MSC) in the movement of military cargo including critical munitions and petroleum products from the U. S. and Pacific regions to the Korean peninsula during the wartime mobilization. A study is needed to evaluate the current and future capabilities, and the characteristics of lift assets and infrastructure related to the KFS Program. Associate Professors Keebom Kang and Ira Lewis, Department of Systems Management, are currently developing a simulation model to study the effectiveness of the KFS Program and to evaluate whether the KFS Program meets the strategic sealift needs of the U.S. Armed Forces. Capt Richard G. Steele, USMC, (December 1999) and Maj Robert S. Gordon, USMC, (December 1999) focussed their thesis research on some of the fundamental issues underlying this study. The results of the study will assist decision makers to determine the need for change in the current program and to identify future requirements.

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CONCEPTS IN LOGISTICS AND TRANSPORTATION MANAGEMENT, *continued from page 6*

A screenshot of the KFS program sealift simulation animation model is shown. The model visually shows movements of ships during the simulation of sealift operation. The visualization tremendously improves communication between analysts and decision-makers. This model was programmed using the simulation package ARENA.

SIMULATION OF KOREAN FLAG SHIPPING IN SUPPORT OF ASSAULT FOLLOW-ON ECHELONS AND FOLLOW-UP SHIPPING

Captain Richard G. Steele, U.S. Marine Corps
Master of Science in Management - December 1999
Advisors: Associate Professors Keebom Kang and Ira Lewis, Department of Systems Management

Sealift is essential in the defense of the Korean Peninsula. This thesis focussed on the activation and assignment of Korean vessels enrolled in the Korean Flag Shipping (KFS) Program. A baseline analysis of the ship data was conducted in order to determine which inputs were available to model. A simulation model based on ship routes, capacities, speed and location were developed to provide a decision framework for the Military Sealift Command. Hypothetical unit data was created with the intent of demonstrating how shipping response times can be generated based on known probabilities from the baseline. Unit closure times were also predicted. Actual operation plan data was not used in the development of this simulation. However, the substitution of actual unit movement data was anticipated and the model was verified to ensure that it could accommodate this requirement.

This research provided a foundation for future simulation of the KFS program. Results indicated that the response times were longer than those currently used. The variability found in both the response times and unit closure times is sensitive not only to the size of the unit to be moved but also to the location of the ship, travel distances, and the allocation of the ships.

A CAPACITY AND COST ANALYSIS OF THE KOREAN FLAG SHIPPING PROGRAM

Major Robert S. Gordon, U.S. Marine Corps
Master of Science in Management - December 1999
Advisors: Associate Professors Keebom Kang and Ira Lewis, Department of Systems Management

South Korea's location forms the intersection of four world powers: Russia, China, Japan and the United States. As such the United States maintains political, economic, and military relations and agreements with the South Korean government for the national security of both nations. One such agreement is the Memorandum of Agreement between the Miitary Sealift Command (MSC) and the Republic of Korea (ROK) which established the Korean Flag Shipping (KFS) Program. The KFS Program (consisting of 59 ships) establishes the procedures and conditions upon which South Korean-flag vessels transfer operations control to MSC and carry United States military cargo in support of the South Korean defense. However, even with the addition of the 59 South Korean Ships, MSC cannot meet the operational requirements for the Korean Peninsula Operation Plan.

This thesis analyzed the KFS Program in terms of ship capacities and South Korean cost considerations, and then recommends viable strategic sealift options that can enhance and/or supplement the KFS Program.

ADVANCED ACOUSTICS RESEARCH LABORATORY

Associate Professor Andrés Larraza
Assistant Professor Kevin B. Smith
CDR Mitchell Shipley, USN
CDR Ed Tucholski, USN
LT Michael Heinemann, German Navy
LT Yong-Hoon Ha, Korean Navy
MAJ Lit-Siew Li, Singapore Navy
LCDR Peer Tas, Royal Netherlands Navy
LT Tom Winter, USN
LT Kirk Weatherly, USN
Department of Physics

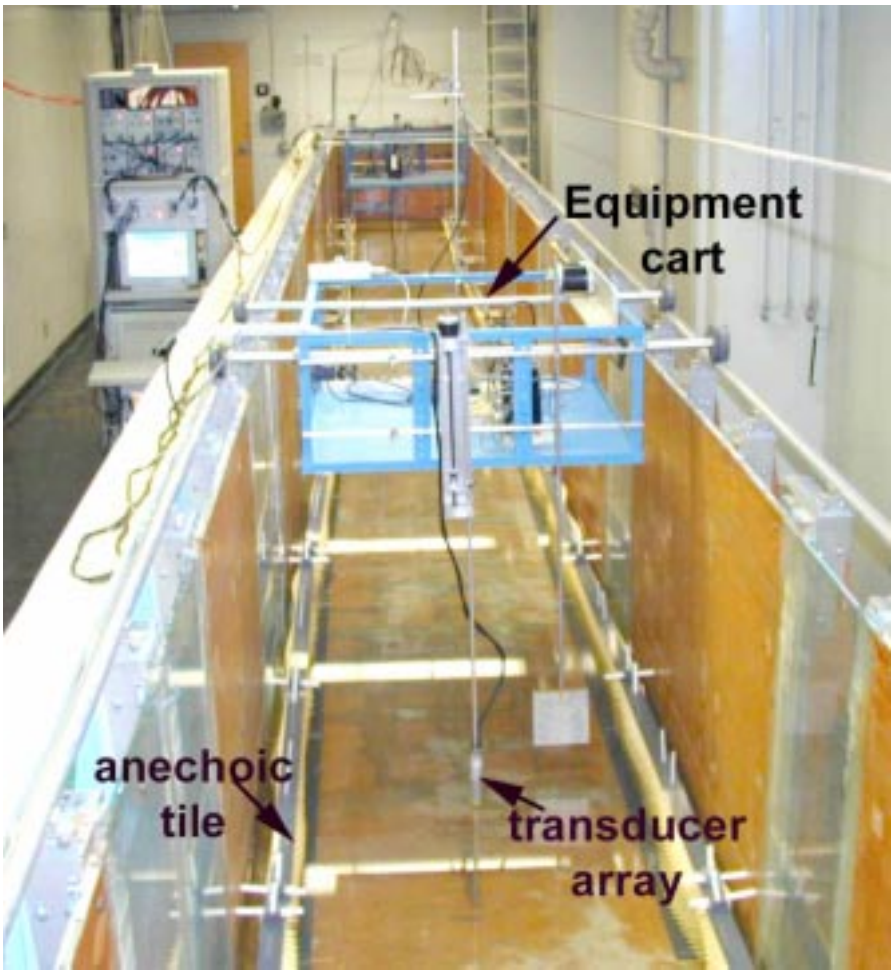

Figure 1. View from above one end of the tank.

The Advanced Acoustics Research Laboratory's (AARL) current research topics involve the separation of particles using high intensity sound waves (acoustophoresis), underwater acoustic communication, environmentally adaptive sonar technologies, passive transient localization of broadband sources of sound, reverberation in shallow water environments, and general features of underwater acoustic propagation. These research areas combine experimental, numerical, and analytical expertise and are funded by the Office of Naval Research and the Space and Naval Warfare Systems Center, San Diego.

The AARL is in the basement of Spanagel Hall, co-located in Room 017 and Room 004B. The experimental laboratory and some of its facilities served previously as an ocean physics research laboratory and had not been in use for almost ten years. The laboratory was refurbished in FY99 to become today a facility frequently visited by scientists from other universities, curriculum sponsors, and flag officers, both from the U.S. and foreign navies.

Two main facilities provide the required experimental environment at AARL. The first is a long tank, shown in Figure 1, made of wooden plates of 18 mm thickness which are sideways reinforced every 65 cm. The inner dimensions of the tank are 15.32 m long, 1.17 m wide and 1.20 m deep. For better water sealing the wood is covered with a layer of fiberglass. The tank rests on a concrete floor on foundation level. Anechoic tiles cover the wall to a height of 28 cm. The anechoic material reduces the echo reflection by about 25 dB in the frequency range between 20 kHz and 100 kHz. Thus, the tank acts as a horizontally infinite waveguide with almost rigid bottom and pressure release surface. In this configuration, the tank serves as a scale model of a shallow water environment, 100 m deep and 8 km in range. On top of the tank sits a rail system on which two carts can move. The carts are able to carry equipment and hold transducer arrays. One of them is driven by a step-motor, which is steered remotely from a computer system. The underwater acoustic communications and the environmentally adaptive sonar technologies research are conducted in this facility.

Most of the acoustophoresis research is done in the second facility which is a tank of wood reinforced fiberglass, of inner dimensions 1.78 m long, 0.86 m wide, and 0.61 m deep. Inserted at the center of both sides of the tank, are 37x27x0.6 cm viewing glass windows (Figure 2).

The infrastructure of AARL is complemented by a wide

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ADVANCED ACOUSTICS RESEARCH LABORATORY, *continued from page 8*

Figure 2. Overview of the apparatus used for acoustophoresis. CDR Ed Tucholski is working in the foreground and Professor Larraza in the background.

range of acoustical and optical diagnostic capabilities and powerful data acquisition systems with graphical user interface windows software developed by LT Michael Heinemann.

Associate Professor Andrés Larraza directs the experimental operation of the laboratory. Assistant Professor Kevin B. Smith, who is also the Chair of the Engineering Acoustics Academic Committee, coordinates the numerical efforts. CDR Mitch Shipley, USN, a military instructor in the Physics Department, brings to the lab extensive programmatic experience as a result of his last tour at the Office of Naval Research where he headed the undersea signal processing team, ONR 321US, and managed the Littoral Warfare Advanced Development (LWAD) Sea Test Program. CDR Ed Tucholski, USN, is conducting experimental and theoretical work for his dissertation as part of the Navy's Permanent Military Professor Program.

AARL provides a cost-effective resource for basic and applied research, where both industrial and Naval applications are pursued. By providing students with innovative and timely thesis topics, AARL supports the educational mission of NPS.

Acoustophoresis

Separation is a very important part in the manufacture of chemicals, plastics, pharmaceuticals, metals, fossil fuels, and plays an important role in the treatment of waste, recycling, and food–processing and biotechnology. A separation process sorts material based on differences in one or more physical properties. For example, filtration separates particles of different sizes, centrifugation separates objects of different densities, electrophoresis separates based on electric charge differences. Water–fuel mixing in many naval ships requires frequent centrifugal separation. The two unwelcome features of this technique are large moving parts and the small metallic particles that they shed; the latter with undesired effects and a requirement for removal or separation.

Acoustophoresis, separation of particles using high intensity sound waves, sorts material based on differences in elastic properties. The techniques in use generally involve fluid flow through a resonator where the standing wave motion is in a direction perpendicular to the flow. This requires careful design of resonant cell configuration for optimal conditions for separations. On the other hand, the Ph. D. dissertation work of CDR Tucholski uses broadband acoustic noise thereby eliminating design restrictions. In particular, the theoretical results by CDR Tucholski and Professor Larraza show that the drag on a bubble or any particle undergoing

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1999 RESEARCH HIGHLIGHTS

SIGNIFICANT RESEARCH EFFORTS AND ACCOMPLISHMENTS IN 1999

Research at the Naval Postgraduate School is an integral part of graduate education. One of the major goals of the NPS research program is to provide cost-effective research and unique research laboratory facilities that permit students and faculty to support Fleet and OPNAV needs. NPS provides independent assessment of proposed solutions to Naval issues, pre-deployment evaluation of new technologies, and combined student-faculty expertise for current research and development programs. Summarized below are a few of the many research efforts and accomplishments of NPS faculty and students during 1999.

One of the major goals of the NPS research program is to provide cost-effective research and unique research laboratory facilities that permit students and faculty to support Fleet and OPNAV needs.

Three faculty in the Department of Systems Management, Professor Steve Mehay, Assistant Professor Mike Cook, and Assistant Professor Kevin Gue, have developed econometric and optimization models that help DoD recruiting commanders decide where to locate recruiting stations and how to allocate recruiters among them. The work is the first to comprehensively incorporate the interaction effects of the Services' recruiting efforts on each other.

Research Associate Professor Jan Breemer, Undersea Warfare Academic Group, contributed to the Chief of Naval Operations' draft Maritime Concept for the Information Age, provisionally titled, *Power...Presence...Knowledge (PPK)*. Professor Breemer worked closely with the document's principal author, RADM Joe Sestak, USN, Director, Strategy & Policy Division (N51). PPK's core ideas evolved from Professor Breemer's article, "The End of Naval Strategy: Revolutionary Change and the Future of American Naval Power," published in the Spring 1994 issue of *Strategic Review*. "The End of Naval Strategy…" has also been required reading at the Naval War College since its publication.

LT Jack Thomas, USN, (September 1999) and Professor Alan Washburn of the Department of Operations Research completed an investigation that delineated the sensitivity of an airborne hyperspectral imager (HSI) used to find near-surface submarines with reflected sunlight. The results showed that HSIs are useful over a large portion of the daylight hours and to sea state 3. The results also showed that HSIs could expect to have best-case sweep widths on the order of 2,000 yards, providing a coverage rate of 180nm^2/hr on a fixed-wing aircraft. This demonstrated that HSIs are suitable for a localization and tracking tool, but not for a search sensor and that HSIs are very effective against relatively shallow submarines under a somewhat narrow set of environmental parameters. (See *NPS RESEARCH*, February 1999.)

LCDR David Varnes, USN, (June 1999), Associate Professor Russ Duren and Professor E. Roberts Wood of the Department of Aeronautics and Astronautics worked with the Naval Air Warfare Center-Aircraft Division VH Systems Engineering Integrated Product Team to develop and successfully

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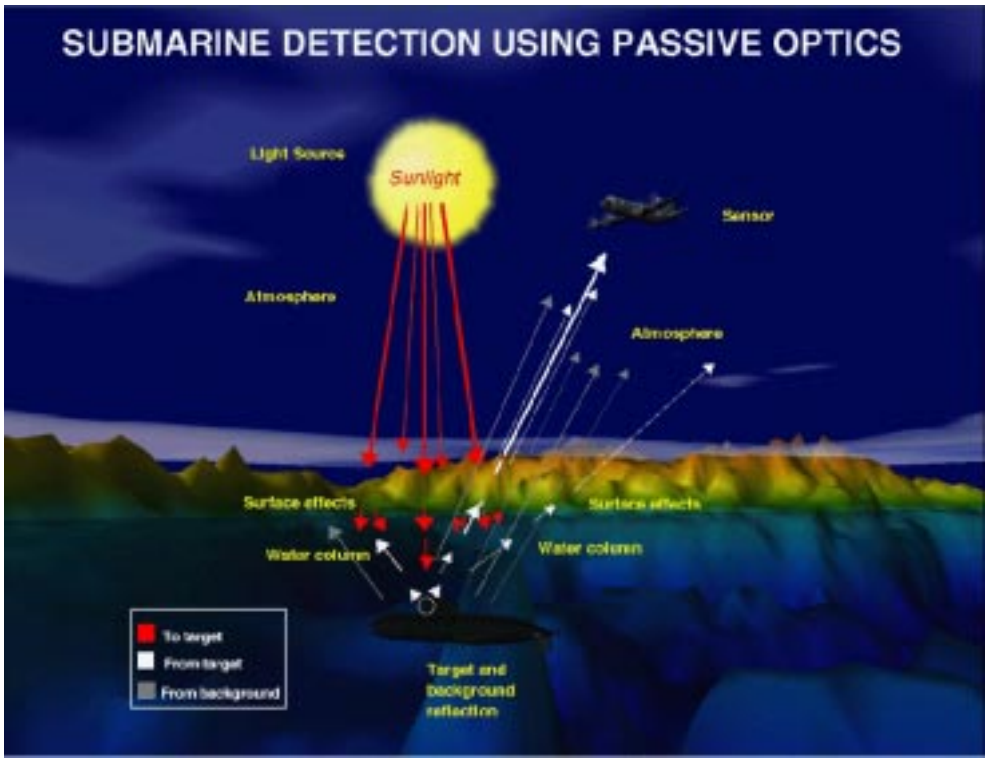
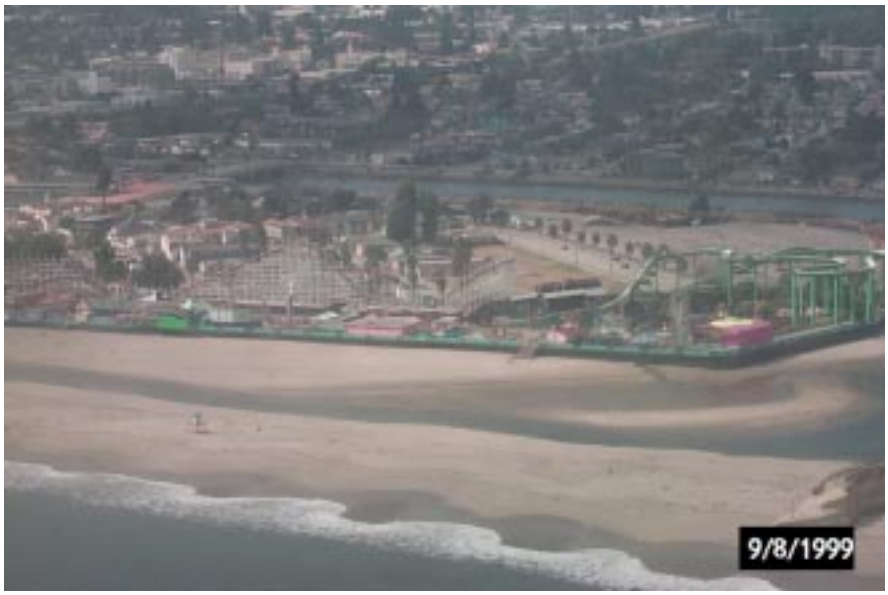


Physical system to be modeled to delineate the sensitivity of an airborne hyperspectral imager (HSI) used to find near-surface submarines with reflected sunlight.

1999 RESEARCH EFFORTS AND ACCOMPLISHMENTS, *continued from page 10*

demonstrate a helicopter vortex-ring state warning system through a moving map display on a kneeboard computer. The VRS program computes and displays a boundary based on the current atmospheric conditions and helicopter weight. The system is connected to the aircraft's avionics data busses as a bus monitor or receiver and requires no modification to existing avionics operational flight programs. (See *NPS Research*, June 1999.)

Several pioneering efforts were completed to demonstrate the utility of wireless local area networks for Naval applications. LT Stephen Tripp, USN (September 1999), CAPT James Powell, USN, Information Warfare Academic Group and Professor Dan Boger, Command, Control and Communications Academic Group, applied a systems engineering process to the selection, evaluation and implementation of a COTS wireless computer network. In-flight evaluation demonstrated the ability to transmit and receive high bandwidth data using the optimized system in a realistic operational environment. LT Robert Moss, USN (September 1999), and the same advisors developed and demonstrated a commercial-off-the-shelf local area network (COTS LAN) for a low probability of detection and low probability of exploitation communications for special operations forces. Both ground and in-flight evaluations were performed to determine component configurations, utilizing a systems engineering approach to achieve maximum range while meeting minimum throughput requirements. (See *NPS RESEARCH*, October 1999.)



LTs Robert Moss and Steven Tripp, flying over Monterey Bay, e-mailed this image via a wireless link to an antenna on the top of Ingersoll Hall on the NPS campus.

In a classified effort, LT Timothy Barkdoll, USN (September 1999), Distinguished Professor Donald Gaver, Department of Operations Research, and CAPT James Powell, USN, Information Warfare Academic Group, determined the improvement in jamming effectiveness obtainable with a hybrid mix of ICAP-III EA-6Bs operating with a distributed network of EW-capable unmanned aerial vehicles (UAVs). The results can be used to assess the practicality of extending the expected service life of the EA-6B through 2015 using a distributed network.

LT George Greenway, USN (September 1999), and Associate Professor Man-Tak Shing of the Department of Computer Science developed and demonstrated a prototype Communications Intercept, Direction Finding, and Analysis System (ACIDS) that was built completely from commercially available components. The system was demonstrated at USNAVCENT (Bahrain) under the sponsorship of the Naval Science Assistance Program (NSAP). (See *NPS RESEARCH*, June 1999.)

LCDR James Townsend, USN (March 1999), and Professor James Taylor of the Operations Research Department developed an analysis tool called the Anti-Ship Missile Defense (ASMD) model. ASMD allows for analysis to be performed from an entire task force perspective, modeling the entire process by which anti-ship missiles select their targets and the methods by which the defending escorts assign defensive fire.

CDR Mitch Shipley, USN, Associate Professor Andres Larraza and Assistant Professor Kevin Smith of the Department of Physics took a new Navy active sonar approach from first concept to at-sea demonstration in the last year. The theoretical basis of the approach involves using time reversal acoustics to remove environmental distortions from active sonar signal returns in shallow water (get "in focus" echoes). Starting around September 1998, Professor Larraza headed up the experimental approach in the departments Advanced Acoustic Research Laboratory (AARL) (see p. 8). In the AARL, a complete scaled version of a shallow water active sonar system was implemented. The results were impressive, with the Time Reversed Acoustic Pulse (TRAP) sonar system

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TOTAL SHIP SYSTEMS ENGINEERING (TSEE) PROGRAM SUPPORTS NAVAL SURFACE WARFARE CENTER SURFACE SHIP TESTING

About 35 visitors recently attended a presentation in the Engineers Auditorium of the 1999 TSSE students' capstone design project of a Surface Warfare Test Ship. They were joined by members of the NPS community – administration, faculty and students. The visitors included senior members of the Navy ship design community as well as a number of interested officers and civilians from the Port Hueneme Division of the Naval Surface Warfare Center. A number of other visitors represented the OPNAV staff, MIT, and a number of NAVSEA and Navy Laboratories organizations.

In order to test shipboard sensors, weapons and systems against realistic threats, the Navy has operated a Self-Defense Test Ship at the Port Hueneme Division for several years. Using this unique ship, self-defense systems are tested against real attacking missiles, (with the ship unmanned and under remote control during such tests). Port Hueneme is hoping to replace the existing Self Defense Test Ship with a ship capable of a wider range of system testing—to be called the Surface Warfare Test Ship (SWTS). The SWTS is expected to be a conversion of a decommissioned ship of the USS Spruance (DD963) Class.

To assist in planning for the new ship, the Self Defense Department Head at Port Hueneme Division, LCDR Jim Childs, requested last spring that the Total Ship Systems Engineering (TSSE) students at NPS assist in its conceptual design. This was the beginning of a very fruitful and interesting TSSE student capstone design project that continued a very valuable trend in the TSSE program, yet was something of a "first" for the program as well.

Port Hueneme's request kicked off the fourth TSSE design in a row that had a "real" Navy customer. During the first four years of this 8-year-old program, the capstone ship design requirements were established by the TSSE faculty, based on realistic concepts for the future, but not necessarily representing a real Navy need. Beginning in 1996, with a request from the Assistant Secretary of the Navy (RD&A) for an Arsenal Ship design, each TSSE ship design has been done in

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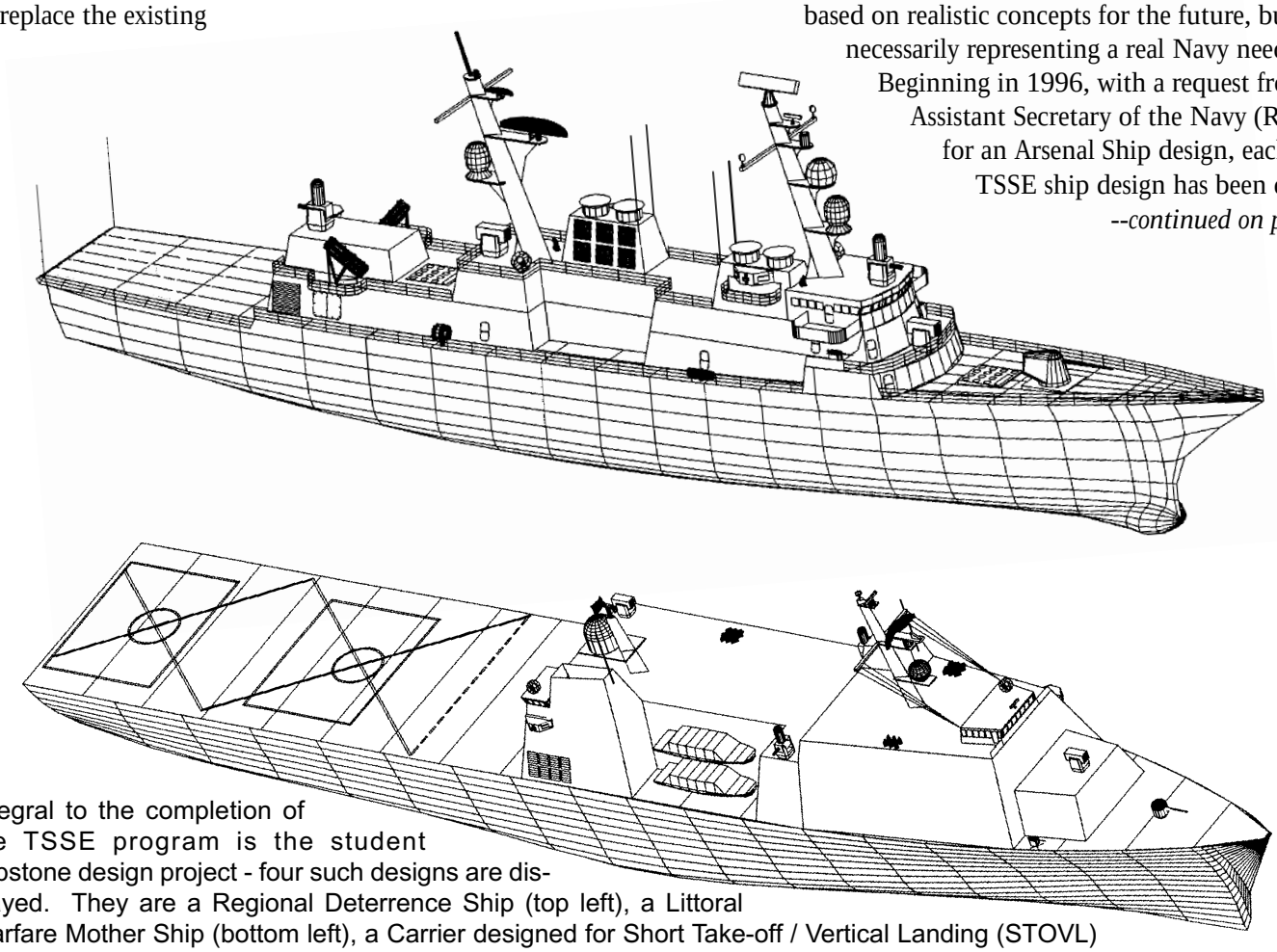


Integral to the completion of the TSSE program is the student capstone design project - four such designs are displayed. They are a Regional Deterrence Ship (top left), a Littoral Warfare Mother Ship (bottom left), a Carrier designed for Short Take-off / Vertical Landing (STOVL) Aircraft (top right) and a Coast Guard variant of a combined USN/USCG Patrol Corvette.

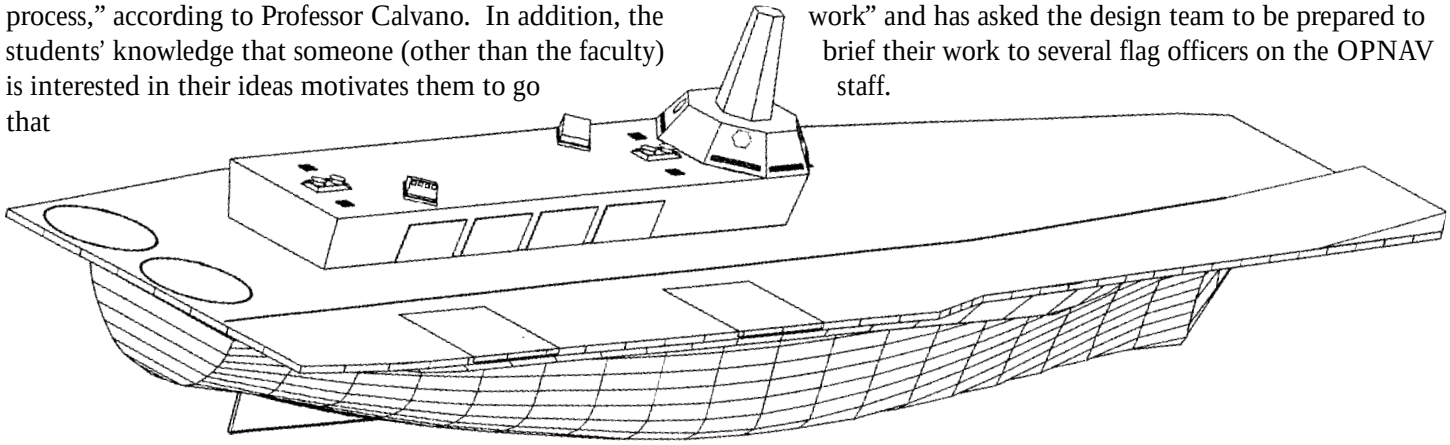
TOTAL SHIP SYSTEMS ENGINEERING (TSEE) PROGRAM, *continued from page 12*

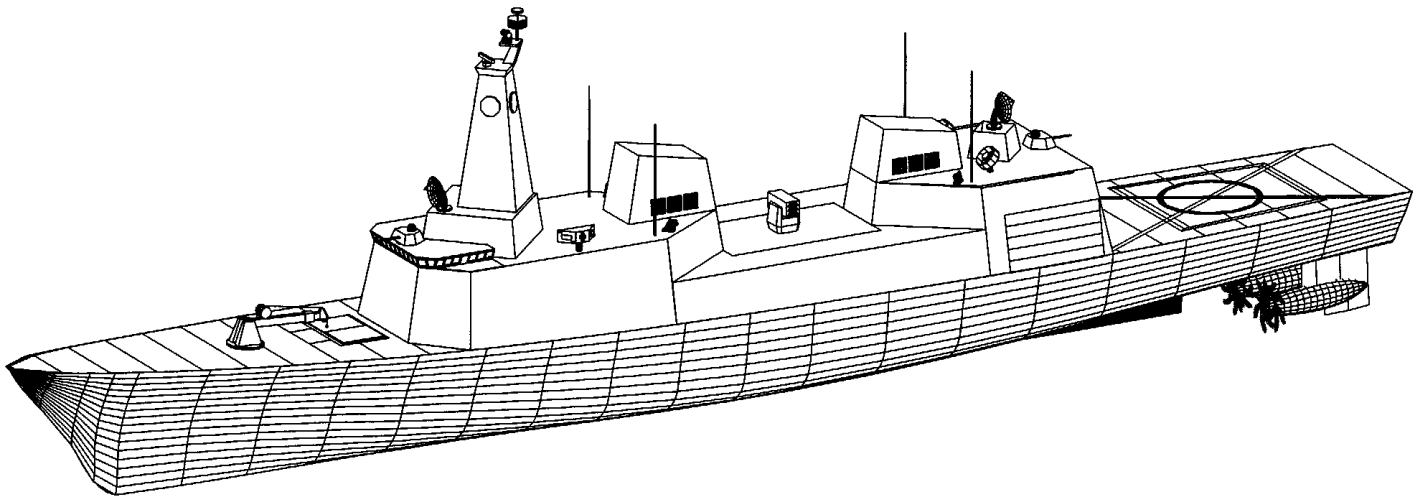
response to a need for the design work by some Navy activity or agency. The Arsenal Ship was followed in 1997 by the design of an aircraft carrier for Short Takeoff/Vertical Landing (STOVL) aircraft (to help the CVN(X) Program Office understand what such a ship might look like). In 1998 a Maritime Preposition Force ship for the 2010 timeframe was designed in response to requirements for new concepts which had been established by the Center for Naval Analyses and the Marine Corps. Port Hueneme's request for help represented a continuation of this trend of the TSSE designs being performed for real "customers."

The TSEE faculty, Professor Chuck Calvano, Department of Mechanical Engineering, and Associate Professor Bob Harney, Department of Physics, believe that having a customer for the annual design increases the educational value of the project while also contributing to student motivation. "The give and take with the customer, including requirements changes as the design progresses, adds to the realism of the process," according to Professor Calvano. In addition, the students' knowledge that someone (other than the faculty) is interested in their ideas motivates them to go that extra mile. Professor Calvano continued, "…and, of course, it's always valuable to show an important segment of the Navy that the Naval Postgraduate School's programs are relevant and responsive to Navy needs, in addition to being academically challenging."

The new wrinkle in this year's project was that it called for a conversion of an existing ship, rather than the design from a "clean sheet of paper" of a totally new ship, which had been the case for all previous TSSE student designs. This factor made many of the design tasks easier, yet made a number of them much more challenging. According to Professor Harney, "It was definitely a worthwhile exploration of a new direction. Now we know there is little need to be concerned that future projects involving ship conversion will reduce the educational content of the capstone project."

The design was begun in July of 1999 and conducted over two quarters. CAPT Jim Phillips, the Commander of the Port Hueneme Division praised the design as "superb work" and has asked the design team to be prepared to brief their work to several flag officers on the OPNAV staff.





AERO PROFESSOR HONORED WITH THE MENNEKEN AWARD FOR OUSTANDING RESEARCH

Associate Professor Isaac I. Kaminer of the Department of Aeronautics and Astronautics is the 1999 recipient of the Carl E. and Jessie W. Menneken Annual Faculty Award for Excellence in Scientific Research. Dr. Kaminer has developed a strong theoretical and experimental research program that supports avionics coursework and thesis students and has been fruitful in producing results that apply advanced theoretical concepts to practical Navy problems.

Isaac Kaminer

Isaac Kaminer joined NPS in 1992 after receiving his Ph.D. in control systems from the University of Michigan. He, together with Associate Professor Russell Duren, comprise the avionics team in the Department of Aeronautics and Astronautics. Avionics is an umbrella of technologies including hardware, software and algorithms that deal with airborne vehicles. His guidance, navigation and control expertise all contribute to the algorithms that integrate all these components. His research interests include modeling, simulation and flight control for air vehicles and conventional weapons.

Dr. Kaminer has been active in both the theoretical and experimental aspects of control theory. One research area in which he has made significant contributions over the past five years is in the design and implementation of gain scheduled controllers where he has several publications. His work also was used in a section of H. Khalil's graduate-level textbook, *Nonlinear Systems*, which is widely used in the field. Another important contribution has been in the area of multidisciplinary aircraft/controller design; several journal publications and conference papers have resulted from this effort in plant controller optimization. A third major contribution is in the field of guidance, navigation and control of autonomous vehicles; this includes airborne unmanned aerial vehicles and underwater vehicles; this is a field where he has many publications and where he has gained international recognition.

Professor Kaminer does not publish alone (with rare exceptions). His journal and conference papers as well as his technical reports include many of his NPS students. Student involvement is integral in his efforts, principally the result of thesis work with occasional directed study work.

Professor Kaminer's research is very relevant to the DoN, DoD and NASA. He has great visibility in the field of avionics with special emphasis in rapid prototyping and UAVs (unmanned air vehicles). The F18 E/F and the Joint Strike Fighter will be the Navy's two major manned aircraft programs in the next 20 years. Avionics upgrades will play a major role in their utilization over that extended time period. UAVs are already becoming a factor in Navy and Joint CONOPS and their usage will no doubt rapidly increase rapidly in the future.

Professor Kaminer is a most deserving recipient of the Menneken Award. His practical implementation of UAV flight controllers for the Navy, his timely advice on other Navy projects, his work with industry and NASA, his ability to attract research fellows and Ph.D. students, and his quality and number of publications all serve to prove his substantial accomplishments. He is a younger faculty member with an already established record of excellence.

Recent Publications

I. Kaminer, A.M. Pascoal, E. Hallberg, and C. Silvestre, "Trajectory Tracking for Autonomous Vehicles: An Integrated Approach to Guidance and Control, *AIAA Journal of Guidance, Control and Dynamics*, Jan-Feb 1998.

C. Silvestre, A. Pascoal, I. Kaminer, and A. Healey, "Plant/Controller Optimization with Applications to Integrated Surface Sizing and Feedback Controller Design for Autonomous Underwater Vehicles," *Proceedings of the 1998 American Control Conference*, Jun 1998.

E. Hallberg, I. Kaminer, and A.M. Pascoal, "Development of a Flight Test System for Unmanned Air Vehicles," *IEEE Control Systems Magazine*, Feb 1999.

E. Hallberg, J. Komlosy, T. Rivers, M. Watson, I. Kaminer, D.E. Meeks, W.J. Lentz, and O. Yakimenko, "Development and Applications of a Rapid Flight Test Prototyping System for Unmanned Air Vehicles," *Proceedings of the 18th International Congress on Instrumentation in Aerospace Simulation Facilities*, Jun 1999.

E. Hallberg and I. Kaminer, "On the Development of the Tail-Sizing Criteria for High-Speed Civil Transport, *AIAA Journal of Guidance, Control and Dynamics*, Jul-Aug 1999.

A. M. Pascoal, I. Kaminer, and P. Oliveira, "Design of the Complementary Time-Varying Filters Using Linear Matrix Inequalities," accepted for publication in *IEEE Transactions on Aerospace and Electronics*.

AWARDS

STUDENT HONORED WITH THE ADMIRAL WILLIAM ADGER MOFFETT AWARD

The 1999 recipient of the Admiral William Adger Moffett Award is CDR Christopher W. Rice, USN. The award is presented annually to an officer student in the Aeronautical Engineering program on the basis of academic excellence, including thesis and career potential. The American Institute of Aeronautics and Astronautics and the Naval Postgraduate School jointly sponsor the award.

CDR Rice enlisted in the U.S. Navy in 1976 and received his commission from the U.S. Naval Academy in 1983 with a B.S. in Aerospace Engineering. After designation as a Naval Aviator in May 1985, he reported to Fighter Squadron One Hundred One for fleet replacement training in the F14A. He graduated from the U.S. Air Force Test Pilot School at Edwards Air Force Base in June 1990. He completed his Master of Science Degree in Aeronautical Engineering in March 1998 and his Aeronautical Engineer Degree in September 1998 at the Naval Postgraduate School. He is currently serving as the Executive Assistant to the Commander, Naval Air Warfare Center-Weapons Division at China Lake, California.

CDR Christopher Rice, with his family, proudly displays the award he has just been presented by RADM Robert C. Chaplin, Superintendent of the Naval Postgraduate School.

QUANTITATIVE STRUCTURAL RELIABILITY ASSURANCE THROUGH FINITE ELEMENT ANALYSIS

Commander Christopher W. Rice, U.S. Navy
Aeronautical and Astronautical Engineer - September 1998
Advisors: Professors Edward M. Wu and Gerald H. Lindsey, Department of Aeronautics and Astronautics

Risk assessment of aging aircraft components can be achieved by operational de-rating using a safety factor subjectively selected from experience and heuristics. This investigation involves synthesizing currently available, maturing computer-aided methods into a format of objective quantitative risk assessment. The methodology is applied to quantify the effect of corrosion on P-3C main landing gear lower drag struts. This kind of synthesis is appropriate wherever structural operational risk is a concern.

The P-3 has undergone many modifications since the 1950s and the lower drag struts are being scrapped due to internal surface corrosion. The corrosion process is random, resulting in pits varied spatially and in severity. These corrosion attributes are merged in a one random variable probability model. The casual relation of the corrosion to structural load is analyzed by finite elements. Computer-aided drafting, verified by physical measurement provides the structural configuration model input. The effect of corrosion on current strut population reliability, as well as the future, is computed. The conclusion is that even under severe corrosion, compressive buckling is not an issue. All the other failure modes (compressive yielding, tensile yielding, and fracture by fatigue) can be assured by one cold temperature proof test.

DESIGN AND ANALYSIS OF A SHIP-BOARD VISUAL NAVIGATION AID FOR VESSELS IN FORMATION

LCDR Thomas V. Evanoff, U.S. Navy
Master of Science in Operations Research-Dec. 1999
Advisors: Assistant Professor William K. Krebs, Department of Operations Research, and Assistant Professor Rudolph P. Darken, Department of Computer Science

This thesis examined the development and analysis of a specialized lighted visual navigation aid, called Tactical Vectoring Equipment (TVE), designed to assist shipboard conning officers when maneuvering in a battle group formation. Piloting at night in close proximity to another vessel can be one of the most challenging and dangerous evolutions at sea. In particular, one of the most demanding tasks is nighttime plane-guard duty. During this evolution, the conning officer utilizes voice radio communications, radar, and visual navigation aids to maintain proper station astern of an aircraft carrier and make maneuvering decisions. However, these visual cues and navigational aids can be ambiguous or time late. Conning officers can experience situational disorientation with their attention distributed between tracking the carrier and other bridge duties. At night, the loss of contrast sensitivity, the lack of daytime visual cues and confusing ship silhouettes can hinder determination of range, course, speed and target angle.

A virtual environment computer model was used to design the specialized navigation aid and measure its effectiveness on subjects. The TVE light display resulted in significantly less range and bearing errors compared to normal navigation lights. This reduced human error, improved ship-handling accuracy and enhanced situational awareness. This is an effective, versatile, and inexpensive device that should be seriously considered for future development and implementation in the fleet. (*LCDR Evanoff received the Military Operations Research Society Stephen A. Tisdale Graduate Research Award in recognition of outstanding achievement in graduate research directed toward improving military force utilization. LCDR Evanoff's next assignment will be serving as the Executive Officer on the USS Mobile Bay (CG53).*

STUDENTS FELLOWSHIPS AWARDED BY THE SPACE AND NAVAL WARFARE SYSTEMS CENTER-SAN DIEGO

The Space and Naval Warfare Systems Center-San Diego (SSC-SD) sponsors a Research Fellowship Program at the Naval Postgraduate School (NPS). The program was instituted to promote SSC-SD's partnership with NPS, address SSC-SD's research focus areas, lay the groundwork for future technical and project management assignments, and foster long-term professional associations with SSC-SD's technical personnel and management. To date, there have been 30 fellowships awarded to NPS students. The fellowship includes a $10,000 award to support the student's thesis research. The most recent awardees are LT Richard S. Cote, USN, LT Elliott T. Dorham, USN, LT Eric C. Lindfors, USN, and CDR Edward J. Tucholski, USN.

LT Cote is pursuing a Master of Science in Information Technology Management. He will be working with Lecturer Rex Buddenberg, Information Systems Academic Group, to study the feasibility of implementing a Virtual Private Network for student and faculty remote access to NPS' secure intranet.

LT Dorham, pursing a Master of Science in Information Technology Management, and LT Lindfors, pursuing a Master of Science in Systems Technology, are both working with Vicente Garcia, the National Security Agency Cryptologic Chair Professor. LT Dorham is investigating security weaknesses of virtual private networks. LT Lindfors' research focuses on evaluating the low cost network intrusion detection software for the network centric Navy.

CDR Tucholski is pursuing his Ph.D. in Physics. Working with Associate Professor Andres Larraza, Department of Physics, his research emphasis is in the acoustics area, specifically the effect of acoustic noise fields on bubbles, or objects of different compressibility than the host fluid. This research has potential implications in wide area acoustic and non-acoustic detection of signal masking, separation techniques for two-phase and immiscible fluids, and heat transfer in two-phase fluids.

AMAZON SURVEILLANCE SYSTEM (SIVAM): U.S. AND BRAZILIAN COOPERATION

Captain Eugene P. Wittkoff, U.S. Marine Corps
Master of Arts in National Security Affairs - December 1999
Advisor: Professor Thomas Bruneau and Senior Lecturer Scott Tollefson, Department of National Security Affairs

The thesis demonstrated how Brazil's System for Surveillance of the Amazon (SIVAM) increases bilateral linkages in Brazilian-U.S. relations within the framework of the international relations theory of complex interdependence. The thesis's central theme was that SIVAM might benefit U.S. national security interests in Latin

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FRAMEWORK FOR FINANCIAL RATIO ANALYSIS OF AUDITED FEDERAL FINANCIAL REPORTS

Captain Richard T. Brady, U.S. Marine Corps
Master of Science in Management-Dec. 1999
Advisors: Associate Professor O. Douglas Moses and Professor Lawrence R. Jones, Department of Systems Management

Federal agencies have traditionally prepared financial reports to monitor and report the obligation and expenditure of federal funding. With the passage of the Chief Financial Officers Act of 1990, Congress called for the production of financial statements that fully disclose a federal entity's financial position and results of operations. The disclosure of this type of information, it was believed, would enable decision-makers to understand the financial implications of budgetary, policy, and program issues and provide an analytical tool for obtaining a deeper understanding of a federal agency's financial condition and operations. The objective of this thesis was to develop a framework for financial ratio analysis of audited federal financial reports to assist in analyzing federal agencies. To accomplish the objective, this thesis identified the reporting models and ratio analysis, identified the existing financial reporting models and ratio analysis frameworks in other sectors of the economy, and identified the financial accounting and reporting environment unique to the federal government. Based upon this archival research, this thesis developed a framework for financial ratio analysis of audited federal financial reports framed around the users and objectives of federal financial reporting. The users of audited federal financial reports can use this framework to assist in agency analysis, assist in decision-making processes, and assist in achieving the objectives of federal financial reporting. (*Captain Brady received the American Society of Military Comptrollers' Award for Excellence in Research, and the Marine Corps Association Superior Service Award for Outstanding U.S. Marine Student.*)

CASE STUDY OF THE UNITED STATES MARINE CORPS ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) PROGRAM TEST AND EVALUATION STUDY

Major Brian K. Buckles, U.S. Marine Corps
Master of Science in Management-December 1999
Advisors: Senior Lecturer Thomas Hoivik, Department of Operations Research, and Research Associate Professor Orin Marvel, Command, Control and Communications Academic Group

This thesis examined the evolution of the Direct Reporting Program Manager-Advanced Amphibious Assault's (DRPM-AAA) test and evaluation strategy from Milestone 0 to the present. The research effort involved reviewing the evolution of amphibious doctrine and amphibious vehicles, reviewing the DoD acquisition process and the role of test and evaluation (T&E) in that acquisition process, and analyzing three DRPM-AAA test and evaluation master plans. Interviews were conducted with personnel from the DRPM-AAA Office and General Dynamics Amphibious Systems. Additional program documents and acquisition literature was reviewed. An analysis of test and evaluation issues facing the Program Management Office, a determination of the effects those issues had on the program's test strategy, and applicable lessons learned were documented for use by other major defense acquisition programs.

Key research findings conclude that: the DRPM-AAA's test and evaluation strategy remained stable and consistent from Milestone 0 to the present as a result of the continuity of the AAAV's key performance parameters; the DRPM's decision to develop a working relationship that "actively engages" both oversight and external agencies early in the test planning process serves in achieving test resource efficiencies; and the Integrated Process Team (IPT) decision-making process differs significantly from the more formal "staff planning process" used by most military organizations. (*Major Buckles received the Monterey Council Navy League Award for Highest Academic Achievement.*)

SIVAM, *continued from page 16*

America, especially in counter-drug operations. For example, an opportunity for greater cooperation between the two nations exists with Relocatable Over the Horizon Radar (ROTHR) data sharing. ROTHR could improve SIVAM's low altitude aircraft coverage and reinforce Brazil's sovereign borders. The most important arena for cooperation is in counter-drug operations.

SIVAM was conceived in the early 1990s to support control and preservation of the Amazon in a strategy known as System for Protection of the Amazon or SIPAM. In 1994, U.S. based Raytheon Corporation won the SIVAM contract over French Thomson CSF in bidding, but contract execution did not begin until 1997. The new Ministry of Defense will probably control SIVAM. SIVAM will have significant surveillance capabilities to support Brazilian military operations other than war (OOTW).

CENTER FOR AUTONOMOUS UNDERWATER VEHICLE RESEARCH

Professor Anthony J. Healey, Department of Mechanical Engineering
Dr. David Marco, Department of Mechanical Engineering
Assistant Professor Donald Brutzman, Undersea Warfare Academic Group
Professor Robert McGhee, Department of Computer Science
Associate Professor Xiaoping Yun, Department of Electrical and Computer Engineering
Mr. Robert Dayap, Department of Mechanical Engineering

Introduction

The Center for Autonomous Underwater Vehicle (AUV) Research has been active in developing Autonomous Underwater Vehicle Technology since 1987. Funded initially by NSF, Professors Healey and McGhee worked to develop a control system architecture for the autonomous control of small unmanned underwater vehicles for both motion control and the control of mission. Doctoral dissertations by Burnes [1], and Marco [2, 3], demonstrated with experimental validation that a three level architecture was suited for this command and control problem. This problem falls into the category of hybrid discrete/continuous systems for which no general theory is available.

Missions for these vehicles include ocean data gathering, monitoring, and others such as mine hunting and neutralization. The NPS *Phoenix* vehicle was built and launched in 1990 as a test-bed vehicle for validation of control concepts. Early missions which the center focused on were those which required thruster control for station keeping near to objects. While the focus of NPS' work was to study thruster controlled behaviors using artificial intelligence, and the three layer hybrid control, other Navy interests (for example, mine search and reconnaissance) required the use of less intelligent vehicles. These were designed to run fixed patterns and collect data such as conductivity temperature density (CTD), and acoustic side scan imagery. In 1990, MIT started their AUV Laboratory in the Sea Grant Program and developed the *Odyssey* vehicles. Woods Hole Institute of Oceanography, funded by the

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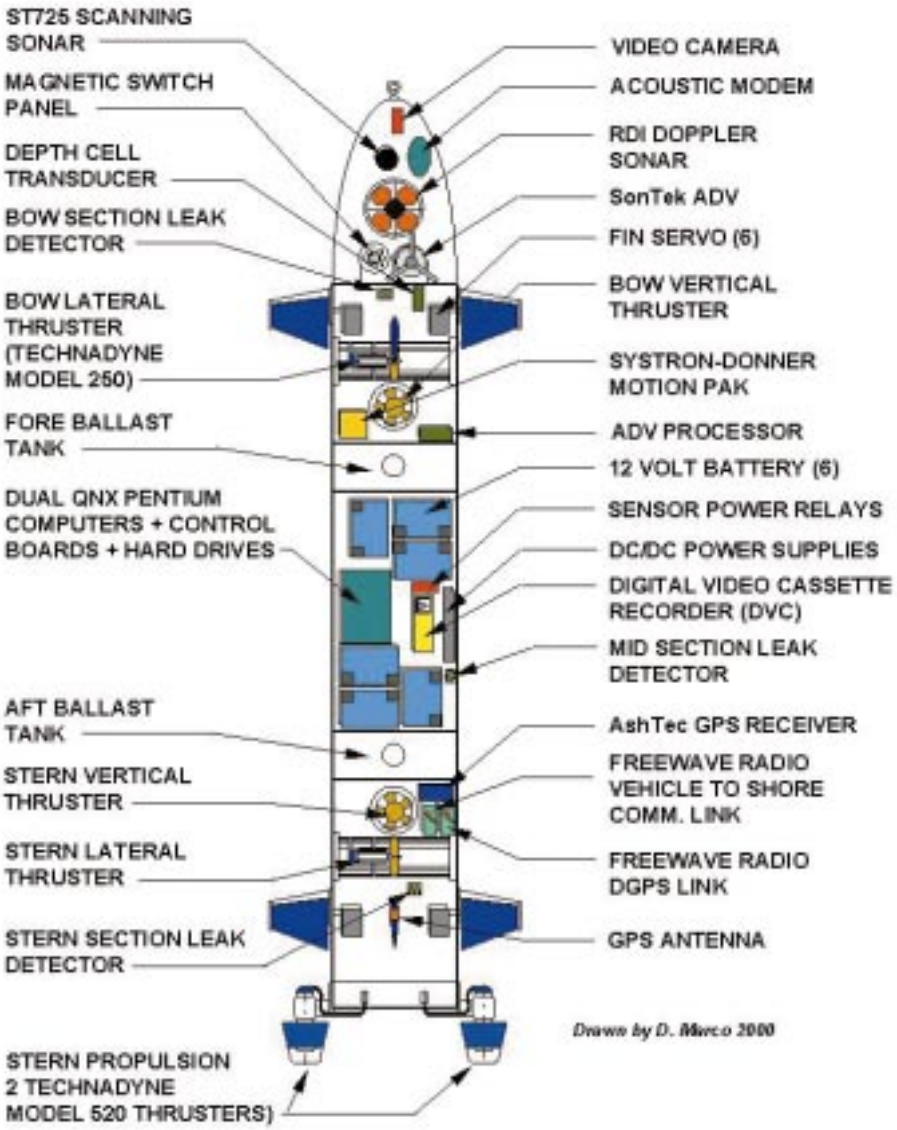
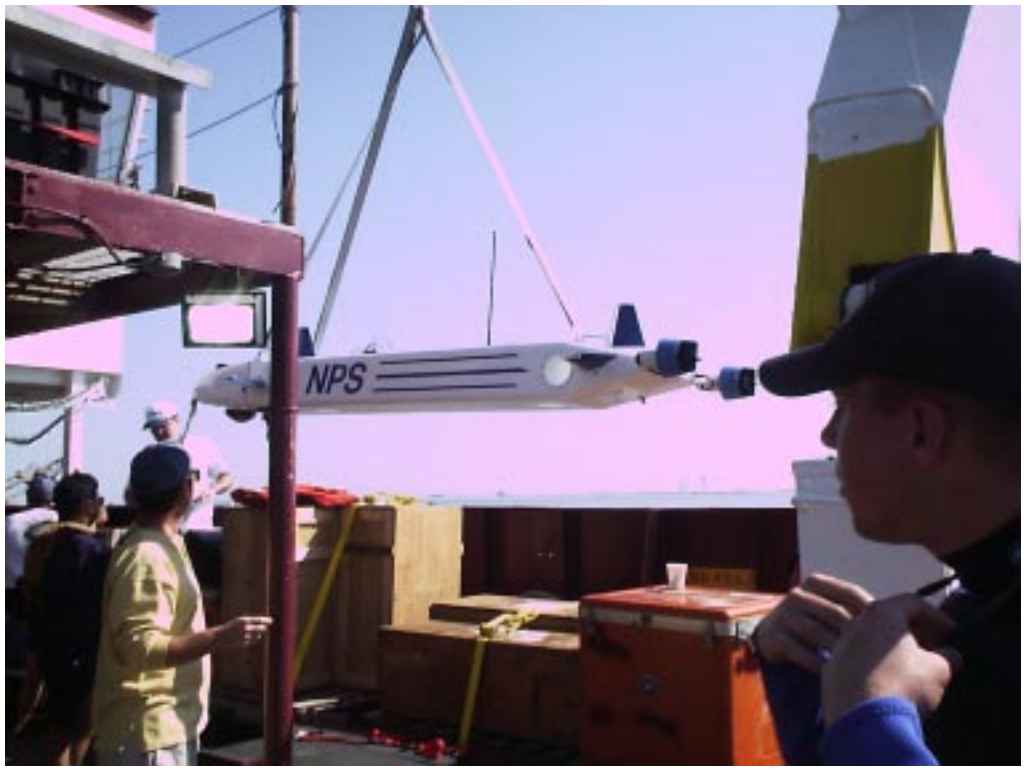


Details of the *ARIES* Autonomous Underwater Vehicle (AUV) for mine reconnaissance / multi-vehicle communications.

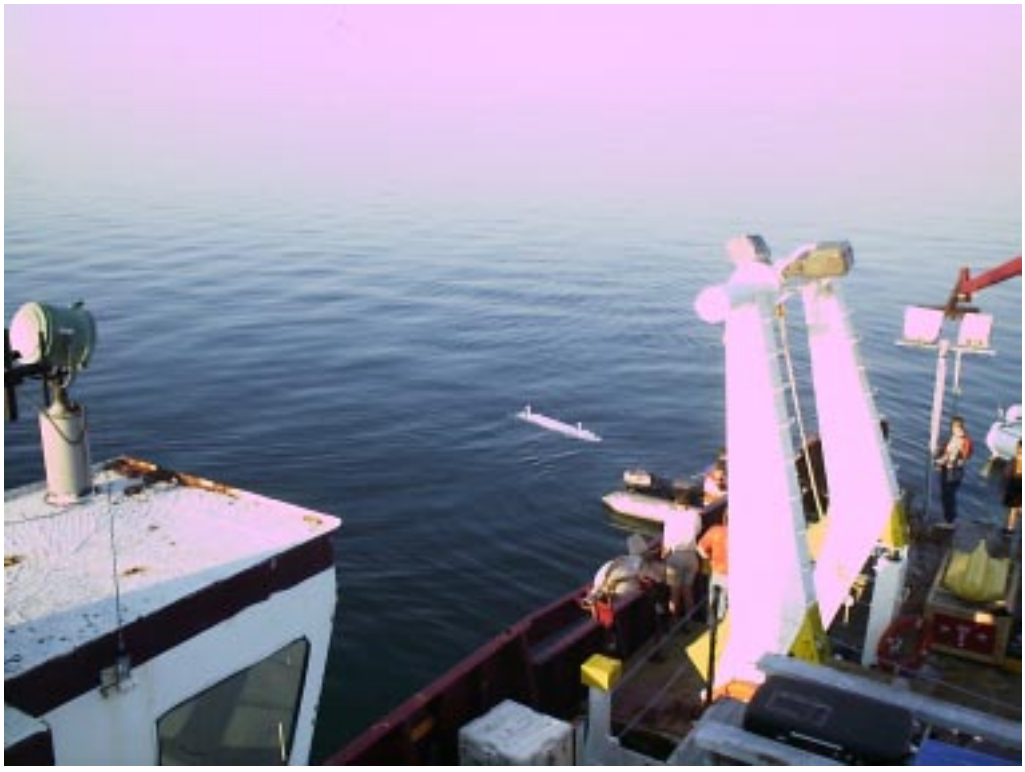
AUTONOMOUS UNDERWATER VEHICLE RESEARCH, *continued from page 18*

Office of Naval Research (ONR), produced the *REMUS* vehicle also for oceanographic survey.

At that time, it became apparent to the Center that our work had to be migrated into the ocean away from the use of swimming pools and test tanks. The dissertation work of Jeff Riedel [4] was therefore focused on work in the ocean performing station-keeping behaviors while learning the sea state and compensating for the action of wave loading. This work led us to be invited to participate in the 1998 AUVFEST. The AUVFEST sponsored by the ONR is a field event to which groups are invited to operate their systems from the *RV Gyre* in the Gulf of Mexico off Gulfport Mississippi. In November 1998, NPS took the *Phoenix* vehicle to its first offshore mission series. In November 1999, NPS took a new vehicle (the *ARIES*) to Gulfport for an experimental series, which now continues in Monterey Bay. The function of the *ARIES* is to act as a server vehicle for underwater networks of vehicles gathering reconnaissance and monitoring data.



***ARIES* Launching from the *R/V Gyre* during AUVFEST '99**



ARIES Vehicle

The *ARIES* was initially constructed in 1998 using partial support from ONR. It was designed to be an operational vehicle in shallow water to 100 meters depth with the purpose of a target reacquisition vehicle as well as a vehicle to test multi-vehicle control algorithms. Subsequently, it is seen to be a

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AUTONOMOUS UNDERWATER VEHICLE RESEARCH, *continued from page 19*

server vehicle for coordinating position and data within a multi-vehicle fleet of robots.

The *ARIES* carries a Differential Global Positioning System (DGPS) Positioning System that is active when surfaced. Underwater navigation, long a subject of interest (Yun et. al., [5], Healey et. al., [6]), is accomplished using an acoustic Doppler velocity sensor under ground lock (RDI Work-horse Navigator) for dead-reckoning, a solid state inertial motion unit, and an NPS developed Extended Kalman Filter for position estimation.

Command and Control is performed through a 900 MHz radio modem when surfaced. While underwater the vehicle is controlled through preprogrammed software. A new software controller has been developed based on double Pentium processors running a real time operating system (QNX) with concurrent asynchronous processes for acoustic and radio communications. Serial and analog I/O are taken in through PC104 boards.

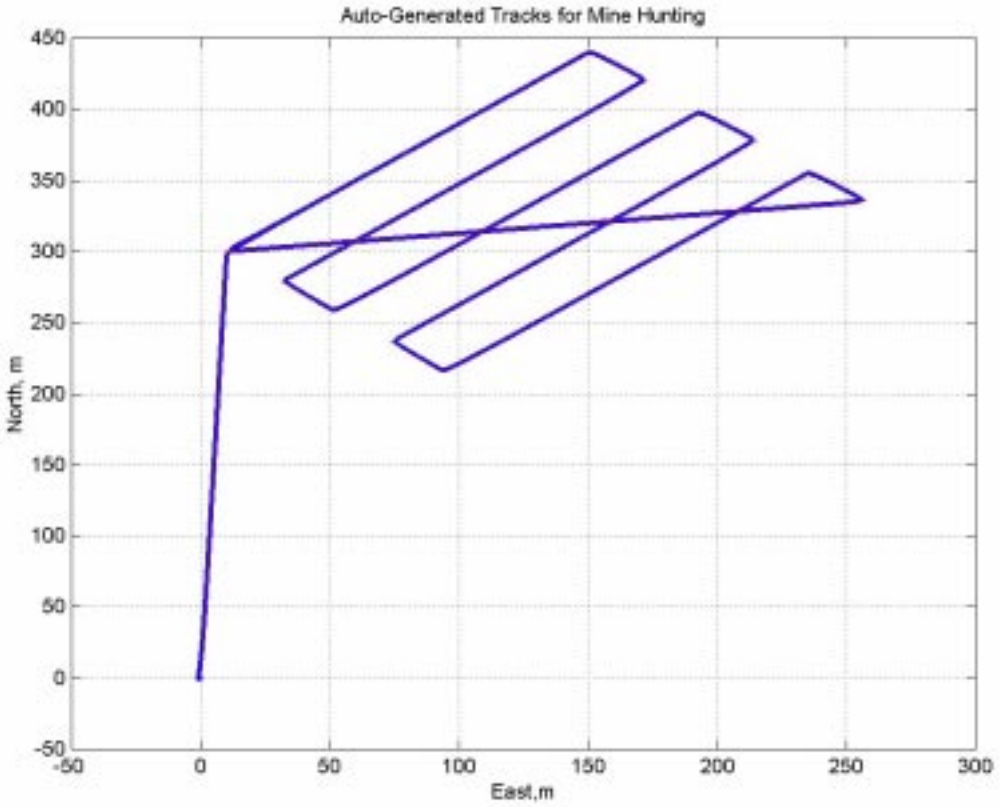

Figure 1. NorthEast Track meters from origin autogenerated during vehicle initialization. The tracks are parameterized by length, width, and angle.

The vehicle is still under development but environmental data gathering missions are planned as well as a simulated hydro thermal vent data gathering mission using both acoustic (scanning sonar) and video imagery.

AUVFEST 99 Main Objectives

The main objectives of AUVFEST99 were to:

- evaluate radio range for the new *ARIES* communications server vehicle
- evaluate the *ARIES* ability to gather and use C4I/DGPS self-position data through single radio link
- evaluate *ARIES* ability to establish video images of bottom/near surface objects
- perform location reacquisition using Doppler/INS/ Compass/DGPS Navigation
- prepare for future inter-vehicle/ surface data communications.

AUVFEST 99 gave the NPS team an opportunity to begin the development of necessary software changes for the full systems integration of *Phoenix* capability into the new *ARIES* vehicle. Some self-propulsion runs were made. Radio command and control functions were demonstrated at almost 2 nmi. DGPS positioning on the surface needs more development, and the full integration of software for the navigation process needs to be completed. This exercise demonstrated the quality of video recording from the *ARIES* that will be used later to image shallow water vents in the AZORES under a NICOP agreement with the University of Lisbon, Portugal.

Minehunting Auto-Track Generation and 3-D Graphics

Brutzman [7] has concentrated on developing 3-D graphics simulators for AUVs which have led to improved understanding of the behaviors of vehicles and which provide a tool for the developing of mission control logic. Also, because missions vary, it has been important to develop user-friendly mission script file generation. This work continues, and as

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AUTONOMOUS UNDERWATER VEHICLE RESEARCH, *continued from page 20*

part of the reduction of mission planning effort, a new auto generation of survey tracks has been developed in which the search pattern can be automated from the specification of a small number of parameters. An example for a lawnmower search is shown in figure 1.

Tactical Decision Aids Using MEDAL

Recent activities have expanded into the development of Tactical Decision Aids using Modeling and Simulation for very shallow water (VSW) minefield searching with AUVs. The work has found that the Navy has such an aid for the mine warfare community called MEDAL - Minewarfare Environmental Decision Aid Library. The system runs inside the Navy's Global Command and Control System (GCCS-M) and is being adapted for the use of AUVs. This activity will be tested this summer as part of the Fleet Battle Experiment-Hotel.

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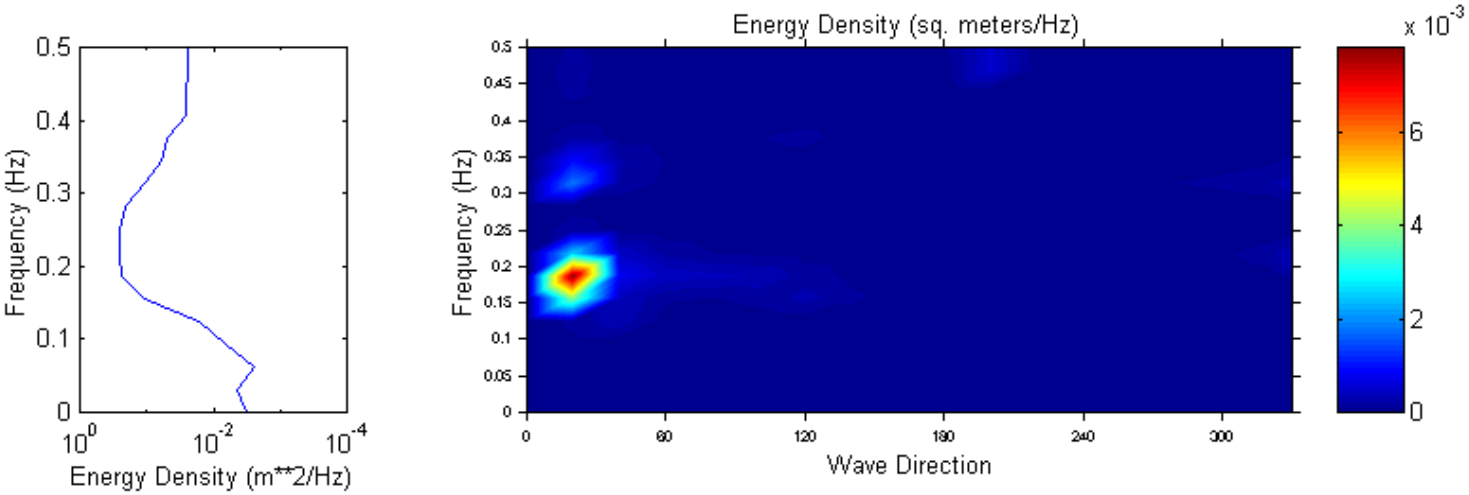
Peak Frequency (hz) / Period (sec): 0.219 / 4.57
Peak Direction: 20 degrees
Max. Energy: 0.007827 m² / Hz



***ARIES* survey data from AUVFEST 99: Path and wave direction**

FACULTY NOTES

AERO/ASTRO FACULTY ELECTED FELLOW OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

Distinguished Professor Max Platzer of the Department of Aeronautics and Astronautics has been elected to the grade of Fellow of the American Institute of Aeronautics and Astronautics (AIAA). AIAA Fellows are persons of distinction who have made notable and valuable contributions to the arts, sciences, or technology of aeronautics or astronautics. For every one thousand voting members of the Institute, one fellow is selected. AIAA is the world's pre-eminent aerospace information resource and the largest professional society for aeronautics and astronautics professionals. Dr. Platzer will be honored and officially confirmed at the Global Air and Space 2000 International Business Forum and Exhibition in May 2000.

Max Platzer

Since joining the Naval Postgraduate School in 1970, Professor Platzer has conducted research on various aerodynamic/aeroelastic problems supported by the Naval Air Systems Command, Naval Air Warfare Center-Aircraft and Weapons Divisions, National Aeronautics and Space Administration (NASA), Army Research Office, Office of Naval Research, and the Air Force Office of Scientific Research. Major results include the development of blade flutter analysis methods (used by NASA, Purdue University, and several turbomachinery companies), analysis of dynamic stall phenomena, experimental studies of flow entrainment and high-lift problems etc.

In 1979, he initiated and negotiated an agreement with the Naval Test Pilot School (TPS) to establish a joint NPS/TPS

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NATIONAL SECURITY AFFAIRS' PROFESSORS FOCUS ON NAVAL STRATEGY

As part of an ongoing effort to help define strategic concepts for the Navy, Professor Douglas Porch and Associate Professor James Wirtz of the Department of National Security Affairs recently published articles dealing with two issues of interest to U.S. Navy strategists and planners. Sponsored by the Office of the Chief of Naval Operations (N3/5), their work focused on the future of carrier battle groups in an era of improving missile technology and on the impact of the Revolution in Military Affairs (RMA). In "The Taiwan Strait Crisis of 1996: Strategic Implications for the United States Navy," published in the Summer 1999 issue of the *Naval War College Review*, Professor Porch explores how the movement of U.S. naval units influenced the behavior of the Chinese government. Porch takes exception with those who exaggerate the impact U.S. intervention on the course of the crisis and warns that improving Chinese area denial capabilities could further reduce the political influence of the deployment of U.S. naval forces in the region in times of crisis. In "QDR 2001: The Navy and the RMA," Professor Wirtz evaluates evidence for the existence of a so-called Revolution in Military Affairs and assesses the way technological change might alter navy strategy and maritime threat environments in the years ahead. Published in the Autumn 1999 issue of the *National Security Studies Quarterly*, the article assesses the way the potential impact of the RMA has been considered in recent Navy war games. Wirtz also offers suggestions about how Navy leaders might portray the Navy's response to the RMA in the upcoming Quadrennial Defense Review and develops a framework for thinking about naval strategy that highlights the importance of placing technological change in a political and strategic context.

FACULTY NOTES

OPERATIONS RESEARCH FACULTY SELECTED AS DISTINGUISHED VISITING PROFESSOR AT THE NATIONAL SECURITY AGENCY

Professor Kevin Wood of the Department of Operations Research has been selected to serve in the post of Distinguished Visiting Professor at the National Security Agency (NSA) during the Summer 2000. His principal responsibility will be to guide ten Ph.D. students in the Summer Program for Operations Research Technology (SPORT). The summer fellows Professor Wood will be advising are selected from among the brightest operations research and math graduate students in the country's top civilian universities. He and the Ph.D. students will investigate a number of operations research problems of interest to NSA, such as network analysis, resource allocation, and scheduling. SPORT's goals are to formulate and solve difficult NSA problems and to strengthen ties between NSA and the broader operations research community. Professor Wood and his NPS thesis advisees already have an extensive track record of successful research performed for NSA.

OPS RESEARCH MILITARY FACULTY PUBLISH TEXTBOOK

LT Mitchell C. Kerman, USN, a military instructor in the Department of Operations Research, and CDR Ronald L. Brown, CDR, USN (Ret.), a former military instructor in the department, have published a textbook. The book was published by Addison-Wesley-Longman in October 1999 (copyright 2000), and is titled, *Computer Programming Fundamentals with Applications in Visual Basic 6.0*.

The book was written for the Introduction to Visual Basic for Operations Research class, OAR 200. It presents concepts of programming methodology and sound software development alongside the fundamentals of the Visual Basic 6.0 language. The goal is to provide a foundation of solid programming techniques and to promote an understanding of the common control structures available in most high-level languages. The book discusses the language with gradually increasing complexity, presenting the essential features of Visual Basic before introducing advanced language features. This is an appropriate textbook for introductory courses in computer programming as well as a reference for advanced programmers.

More information about this textbook can be found on line at: http://www.awlonline.com/product/0,1992,0201612682,00.html.

NPS faculty sometimes have to get very involved with their research projects on a personal basis in order to obtain the necessary data to complete the project. Professor **Morris Driels**, Department of Mechanical Engineering, does research with the Joint Munitions Effectiveness Manuals in connection with target acquisition using visual and FLIR sensors. In order to be able to experience the use of optical aids and FLIR sensors first hand he undertook water survival and aviation physiology training to enable him to fly "back seat" in U.S. Navy aircraft. So far he has flown with VS-35 at NASNI-San Diego, but flights with F18s are anticipated.

AERO/ASTRO FACULTY ELECTED FELLOW, *continued from page 22*

curriculum. Under this agreement select Navy officers first come to NPS for one year and then go to TPS for their second year. This program enables them to receive a Master's degree in aeronautical engineering with a specialty in flight testing. This program has been in effect since 1980 and is considered highly successful and desirable by both institutions.

In 1986, Professor Platzer established a joint institute between the Naval Postgraduate School and the NASA Ames Research Center for the purpose of enabling NPS faculty and students to participate in NASA research programs and to make use of NASA facilities and expertise. Under this agreement over 40 students performed their thesis studies at NASA Ames. Major research projects conducted in the joint institute involve computational and experimental studies of helicopter blade stall and high-angle-of-attack aerodynamics of fighter aircraft and missiles.

Professor Platzer is currently serving as Chair of the Department of Aeronautics and Astronautics and Director of the NPS-NASA Joint Institute of Aeronautics. Dr. Platzer is also a Fellow of the American Society of Mechanical Engineers.

1999 RESEARCH EFFORTS AND ACCOMPLISHMENTS, *continued from page 11*

demonstrating twice the signal-to-noise ratio as compared to standard active sonar matched filtered techniques. Professor Smith headed up an AARL computer modeling effort that extended the concept from the simple laboratory environment to more realistic shallow water ocean environment. His work with LT Antonio Abrantes, USN (June 1999), was recognized with an outstanding thesis award. Through the Office of Naval Research's (ONR) Littoral Warfare Advanced Development (LWAD) program, CDR Shipley took the laboratory system to sea in September 1999 off the coast of Oregon and employed it against a diesel electric submarine in a real world shallow water environment. Although the analysis of that test is not yet complete, the demonstration of the TRAP sonar system concept in real time at sea was an unqualified success.

LT Jeffrey Bennett, II, USN (December 1998), Professor Don Walters, Department of Physics, and CAPT James Powell, USN, Information Warfare Academic Group, investigated high-power radar effects on anti-ship missiles. The susceptibilities of anti-ship missiles to high-power radio frequency (RF) or High Power Microwave (HPM) effects were documented. An analytical approach to anti-ship missile vulnerabilities was developed. That was followed by the results of three U.S. Navy Electronic Warfare (EW) tests with fleet units. This was a classified shipboard RADAR project involving Directed Energy Warfare (DEW), and the research proposed use of current shipboard capabilities to defeat anti-ship missiles. A test was conducted with the *USS COWPENS (CG-63)* supported by Naval Air Warfare Center-Weapons Division at China Lake, CA, which verified the desired effects against current missile threats. Dynamic flight tests were conducted with the *USS MAHAN* using the NRL RP-3D P-3 aircraft with actual threat missile simulators that bounded the effects on missile seeker operation. This research has immediate tactical significance for Fleet units to provide insight into possible RF effects, and to develop an additional tier of defense-in-depth for deployed battlegroups and future surface combatants using HPML.

NPS conducted other High Power Microwave (HPM) research at the Special Access Program level involving six students and five faculty during 1999. A new class in HPM, Radiofrequency Weapons, High Power Microwaves, and Ultrawideband Systems (PH4056/EC4960) taught at the SECRET level was also offered for the first time. Research project results conducted in conjunction with this class and a panel of national experts in HPM were incorporated in the National Intelligence Estimate (NIE) on RF Threats to the National Information Infrastructure published by the CIA in May 1999.

LT Ray Buettner, USN, and CAPT James Powell, USN, Information Warfare Academic Group, applied SAIC's SIAM Influence Net Modeling Tool to exercises and real-world CINC support in developing innovative information operations (IO) options to address the requirement for IO modeling and simulation (M&S). IO M&S has been a top three recommendation from U.S. Atlantic Command's landmark EVIDENT SURPRISE exercises. An influence net model of a targeted country was the initial effort conducted with the assistance of SAIC and the ACOM J5; developmental IO options were integrated, and the interaction and effects on leadership demonstrated. The result was a first-look simulation of how leadership can be influenced by IO in real-world contingencies. NPS student and faculty researchers have demonstrated the results of this analysis to SECNAV, CINCUSACOM, CINCUSNAVEUR, DIRNSA, and other high-level decision-makers to show SIAM's value as an IO influence modeling and decision aid, and modeling and simulation research tool.

Professor Mike Melich and Professor Pat Parker, Institute for Joint Warfare Analysis, together with many students conducted a three-year ONR/NPS/SSG project on force structures for the year 2020. The major achievement of the work was the demonstration of a logical method for building geopolitically reasonable, cost constrained, technologically consistent forces for the United States and potential competitors.

In a project for the Marine Corps, Associate Professors Bill Gates, Department of Systems Management, and Young Kwon, Department of Mechanical Engineering, along with LCDR Tim Anderson, USN, and Professor Alan Washburn of the Department of Operations Research, studied the future of the fleet of KC130 aerial refueling aircraft. Using present value analysis, they established that the current fleet of aging F/R series aircraft should be retired in favor of new KC130J aircraft. They also studied the requirement for these aircraft in a major war in about the year 2015, including nonrefueling missions such as cargo delivery and maintaining aerial command posts. The total requirement for KC130J aircraft in 2015 is about 100, with reasonable variations on the base case changing that number by a factor of two (see p. 4).

CONFERENCES / SHORT COURSES

FOURTH INTERNATIONAL SYMPOSIUM ON TECHNOLOGY AND THE MINE PROBLEM

The Fourth International Symposium on Technology and the Mine Problem will be held 12-16 March 2000 at the Naval Postgraduate School. A distinguished group of senior military officers (led by the Commandant of the Marine Corps, GEN James L. Jones, USMC), senior civilian policy makers, and invited presenters, have been assembled. Each of the previous Symposia has attracted attendees from abroad, from the serving military of all services, from industry, from academe, and from the Government laboratory, and program sponsorship communities. This periodic Symposium is recognized as the premier event of its kind in the World. It is unique in that it brings together all aspects of the Mine Problem: Mine Technology; Naval Mine Warfare; Land Mine Warfare; Humanitarian and Peacekeeping Demining and Unexploded Ordnance (UXO) Site Remediation; and Emerging Technology. The purpose of this Symposium Series is to change the world of the Mine/UXO Problem. The theme for the 2000 Symposium is "Where We Are; Where We Are Going."

Registration information and program details can be obtained at http://www.demine.org or by calling (831)373-0508.

CLASSIFIED ADVANCED TECHNOLOGY UPDATE SHORT COURSE

The Naval Postgraduate School will sponsor the Second Annual Classified Advanced Technology Update (CATU). Hosted by Professor Herschel H. Loomis, Department of Electrical and Computer Engineering, and Professor Vicente C. Garcia, National Security Agency Cryptologic Chair Professor, the course will be held 28 February to 3 March 2000.

The CATU is intended for TOP SECRET/SCI-cleared military and civilian technical personnel who are interested in refreshing and updating their knowledge in the areas of advanced technology, which support the mission of the Department of Defense. Speakers, from both industry and government, have been selected based on their work in the technical areas and their recognized subject matter expertise. Course topics will include Cryptology, Information Operations, Overhead Reconnaissance, Digital Signal Processing, Navigation, Communications, High Power Microwave and Geolocation.

Registration information and program details can be obtained at http://www.sp.nps.navy.mil/CATU or by calling (831)656-2110/2148.

TECHNOLOGY REVIEW AND UPDATE

The Naval Postgraduate School will offer the seventeenth Technology Review and Update Course for Technical Personnel the week of 24-28 April 2000. Professor Rudolf Panholzer, Dean of Science and Engineering and Chair of the Space Systems Academic Group, coordinates the course.

The course is presented at the unclassified level. Session presenters will be from academic and industry. Sessions will cover:

- Internet Technologies
- Electro-Optical and Infrared Systems
- Micro Electro-Mechanical Systems (MEMS)
- Optical Sensing Technology
- Military Satellite and Communications Technologies
- Satellite Communication Technologies and Trends
- Integrated Circuits
- Computational Intelligence

The course is intended for military and civilian technical personnel interested in refreshing and updating their knowledge in the areas listed above. The course provides an excellent overview and stresses the more practical aspects of the topics listed.

Registration information and program details can be obtained at http://www.sp.nps.navy.mi./trau00 or by calling (831)656-2948.

DEFENSE TECHNOLOGIES FOR THE NEW MILLENIUM

Associate Professor Phillip Pace of the Department of Electrical and Computer Engineering will host a three-week short course for the Swedish National Defence College (NDC). This year's offering is titled "Defense Technologies for the New Millenium." The course is scheduled for 20 March through 7 April 2000. Twenty-three students from NDC have been selected to attend. Course sessions will cover: Unmanned Aerial Vehicle Payloads and Links, Modeling the Decision Process, Information Operations, Cruise Missile Technology Modeling and Simulation, Atmospheric Predictions, Tactical Operations Analysis, Ultra Wideband Impulse, Weapons Effects, Network Centric Radar EW, RCS/LCS Engineering, and ATM/Gigabit Ethernet Technologies.

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NPS AND THE NAVAL AIR SYSTEMS COMMAND TAKE ANOTHER STEP TO FORGE A CLOSER RELATIONSHIP

The efforts of the Naval Postgraduate School and the Naval Air Systems Command (NAVAIR) to establish the NAVAIR Chair and Liaison has finally became a reality. Ms. Jan Young, Deputy Director of the Cost Department at NAVAIR, was jointly selected as the first incumbent for this new position. Ms. Young brings a wealth of knowledge of the acquisition process and a broad base of contacts in NAVAIR, the Office of the Secretary of the Navy, the Office of the Secretary of Defense, and the other Services to this position. As a member of the NAVAIR team for the past 13 years, Ms. Young has supported, directly or indirectly, the majority of programs in NAVAIR. She also recently completed her work as a Focus Group Leader and the Navy Representative for the Price-based Acquisition Study, sponsored by the Undersecretary of Defense (Acquisition, Logistics, and Technology).

One of the goals of the liaison position is an opportunity to share knowledge. It is another means of bringing a multi-talented team to bear on current technical issues that are affecting fleet operations. Many of the students at NPS, rotating in from fleet duty, bring current fleet issues into the classroom--issues that often become the basis for their thesis. They want to be actively involved in developing solutions. NAVAIR may already have engineers working on the same or similar issues.

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Students come to NAVAIR looking to support on-going initiatives or to conduct research on 'hot topics.' By bringing students together with NAVAIR personnel, the student gains a mentor and has an opportunity to develop a solution to a real problem. On the other hand, NAVAIR personnel have an opportunity to increase their knowledge of current Fleet issues and to better understand how the Fleet is being affected by decisions made at NAVAIR. Add in the expertise and experience of the faculty at NPS, and the team only gets stronger. Faculty members stay current with new technology, new trends in industry. They bring this knowledge to any project they support. In return, they have opportunities to remain current on NAVAIR activities. This is information they can then take back to their students. There is one more piece to add —participation of industry. Because NAVAIR and industry representatives are often working together to resolve problems, students participating in such projects also get the added benefit of working with industry.

With Ms.Young's background in cost estimating and analysis, one of the first things she has been asked to do is to develop 'cost curriculum.' The role that cost estimating and analysis is playing in current acquisition decisions is evident. NPS wants to ensure students are cognizant of current initiatives such as Total Ownership Cost, Affordable Readiness, and Cost As An Independent Variable, and how these initiatives relate to the engineering discipline. Students will also be provided with an understanding of the tools they may use for monitoring contractor performance, such as Earned Value Management, if they should become a Class Desk or Program Manager in the future.

Working with Assistant Professor Russell Duren of the Department of Aeronautics and Astronautics, Ms. Young introduced the topic of software cost estimating and project management to his Avionics Design class. The possibility of designing a class around a current NAVAIR program such as the Mission Computer Upgrade for the E-2C is being discussed.

Expanding the mentor program, bringing NAVAIR engineers together with students, while bringing additional research funds to the NPS, will be major focus areas for Ms. Young. She is also working with CDR Mike Couch, USN, a military instructor in the Department of Aeronautics and Astronautics, to resurrect the weekly guest speaker series. The focus is mainly on bringing in NAVAIR Program Managers or Integrated Project Team (IPT) leaders who can talk about on-going engineering challenges in their programs. To add variety to the program, senior Navy leaders will be invited to speak about issues affecting the Fleet.

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RELATIONSHIPS

NPS PARTNERS WITH THE DIRECTOR OF EXPEDITIONARY WARFARE AND THE CHIEF OF NAVAL RESEARCH

A Memorandum of Understanding has been initiated to establish and support a Chair of Expeditionary Warfare at the Naval Postgraduate School. Expeditionary Warfare occupies a central position in implementation of *Forward…From the Sea* and other concepts of 21st century warfare. A Naval Postgraduate School initiative is to enhance the expeditionary warfare academic and research content of its programs. The Institute for Joint Warfare Analysis (IJWA) at NPS will take the lead in applied research in this area and also support curricula. IJWA and the Center for Naval Warfare Studies at the Naval War College coordinate a study group for N85 to define and evaluate expeditionary warfare concepts and to determine requirements and shortfalls to assist N85 in defining expeditionary warfare program directions. The Chair will bring additional expertise to NPS in this crucial warfare area, provide research and curricular leadership, and enhance coordination of activities in the area between N85, ONR and NPS programs.

The first Chair of Expeditionary Warfare will be Dr. Phil Depoy. A graduate of Stanford University with a Ph.D. in Chemical Engineering, Dr. Depoy has a broad range of experience to bring to the position. He most recently served as the President and CEO of the National Opinion Research Center. Previously, Dr. Depoy spent 33 years with the Center for Naval Analyses (CNA) holding a variety of positions to include President and CEO and Distinguished Senior Fellow.

CONFERENCES, *continued from page 25*

JOINT MUNITIONS EFFECTIVENESS MANUAL (JMEM) AIR-TO-SURFACE OPERATIONAL USERS WORKING GROUP (OUWG) MEETING

A three-day meeting brought together operational members of the OUWG to discuss their particular weaponeering needs and requirements. In particular, one focus of the meeting was the latest release of the Joint Air-to-Surface Weaponeering System (JAWS). Another focus of the meeting was on weaponeering lessons learned from Operation Allied Force/Noble Anvil. Professor Morris Driels, Department of Mechanical Engineering, served as the NPS host to about 60 aviators and strike planners attending the meeting in November.

RELATIONSHIP RENEWED BETWEEN NPS AND THE NAVY SPACE SYSTEMS DIVISION (N63)

The Memorandum of Agreement between the Naval Postgraduate School (NPS) and the Navy Space Systems Division (N63) was renewed recently for an additional three years. The agreement establishes the organizational relationship regarding the Navy Tactical Exploitation of National Capabilities (TENCAP) Space Chair at NPS.

One of the primary goals of Naval Space Policy is to, "exploit the unique benefits of space in order to support operational naval forces." Navy TENCAP has historically been a leader in this area. The principal objective of the TENCAP Space Chair is to provide a direct relationship between, NPS, Navy TENCAP (N632), and industry for mutual cooperation and benefit. This relationship provides a mechanism by which students can gain familiarity and exposure to existing and emerging technologies within industry and their applications to naval space programs and associated fleet support. Dr. Alan Ross continues as the Navy TENCAP Chair incumbent.

NPS AND THE UNIVERSITY OF SOUTH AUSTRALIA ESTABLISH AN INTERNATIONAL SYSTEMS ENGINEERING ACADEMIC ALLIANCE

A Letter of Intent has been signed between the Naval Postgraduate School (NPS) and the University of South Australia (UniSA). The purpose of the agreement is to create an alliance for the mutual development of academic contributions to Systems Engineering in defense and commercial applications. The Alliance will initially consist of NPS and UniSA but other university groups will be encouraged to become members of the Alliance. Similarly industry and government parties will be encouraged to participate in the Alliance.

The objective of the Alliance is to provide a framework for effective collaboration among members. It will consist of members giving access to each other of their teaching expertise, research findings and experience in areas identified by the Alliance as key opportunities for furthering the maturity of academic Systems Engineering. The Alliance will cover materials and expertise that are available within the defense and industry base, subject always to national accessibility constraints.

SMALL BUSINESS INNOVATIVE RESEARCH (SBIR) PHASE II AWARD RECOMMENDED FOR THE DEVELOPMENT OF AN INTRINSIC EARTH SURFACE MATERIAL CLASSIFIER SYSTEM

Assistant Research Professor Wolfgang Baer, Department of Computer Science, together with Research Associate Bob Bluth, Director of the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS), have recently concluded two Phase I SBIR contracts and recommended the award of a Phase II SBIR contract for the development of an intrinsic earth surface classifier system. The system will be designed to reduce high-resolution remote sensing data from satellite and aerial sensors to permanent ground properties descriptors.

The computer simulation community requires the capability to quickly and easily calculate realistic scenes, which accurately represent the real world. In order to achieve this capability a standard database of surface materials, characterized by intrinsic physical properties is required. A database of intrinsic physical properties will give simulation developers the ability to create realistic surfaces; complete with expected spectral responses at any wavelengths, observation geometries, and environmental conditions. The goal of our effort is to build the infrastructure for the construction of such an earth surface material database with one-meter resolution.

Current databases are woefully inadequate to address the needs of metrically accurate simulation. Vast amounts of source material are available in locally calibrated, project-specific databases and more data are being collected as additional multispectral and hyperspectral systems become operational. But, this material exists in a myriad of formats, degrees of completeness, and levels of data quality and, as a result, almost none of these data are directly usable for enhancing physical realism in computer simulation applications.

Tools for extracting intrinsic properties of material from remotely acquired data are basically nonexistent and the suites of surface rendering tools currently available are limited in scope; in other words, they cover an abbreviated wavelength range or include only a limited set of material types.

The Similation Interoperability Standards Organization (SISO) Intrinsic Earth Surface Material Classifier System project will develop the definition of a Standard Surface Material Code (SSMC). To a modeling and simulation program, such a code acts like a pointer to a list of intrinsic earth surface material parameter values that define the physical and radiometric properties of the surface over a broad wavelength range. This information will reside in the Surface Materials Standards list - RESOLVE (Radiometric Earth Surface Observables for Land Visualization Events), which includes materials based on the global abundance of naturally-occurring, man-made, and non-realistic materials, their significance (e.g. importance) to a user community, and availability of spectral data sources to support extraction of intrinsic surface properties. The standard will also include reversible surface rendering and atmospheric propagation equations to allow a traceable connection between measurement and database content.

The standard and software infrastructure to model the earth at one meter resolution is being built today to be ready for the hardware capacities expected to be available on the desktop tomorrow. “We are already behind,” says Dr. Baer, who believes the software and algorithm development is not keeping up with machine capacity in many areas. Remote sensing data reduction is only one of them.

COOPERATIVE RESEARCH AND TECHNOLOGY BROKERING

A Memorandum of Understanding (MOU) is about to be finalized to establish a formalized relationship between the Naval Postgraduate School (NPS) and the Federal Technology Center (FTC). The purpose of the agreement is to provide a framework for partnership development and technology commercialization by FTC of NPS intellectual property.

NPS has considerable intellectual property (patents, software, solutions to emerging technology needs). Alternatives have been examined for an improved technology transfer program that is both more cost effective and that can reach a broad technology market. The results of that examination have led to the MOU, which will establish an initial trial program to utilize the skills of FTC to market NPS intellectual property with no direct costs to NPS.

The Federal Technology Center is a not-for-profit, public benefit California corporation dedicated to Federal technology transfer and economic development. The mission of the FTC is to promote technology innovation and small business development through sponsoring federal laboratories’ technology transfer initiatives.

RESEARCH LEADS TO PATENTS FOR TWO NPS FACULTY

Patents were recently issued by the U.S. Patent and Trademark Office to two NPS faculty members, Distinguished Professor Max Platzer of the Department of Aeronautics and Astronautics and Assistant Professor Tom Hofler of the Department of Physics. Both faculty have extensive research programs in the topical areas that produced these patents.

HEAT DRIVEN ACOUSTIC POWER SOURCE COUPLED TO AN ELECTRIC GENERATOR (U.S. PATENT NO. 5,996,345) (T. J. Hofler)

The electricity-generating engine has modest efficiency, but may be attractive in remote applications where high-reliability of low cost or low environmental noise or solar powering is important. The generator is likely to be most attractive in capacities of a few kW to below 100W where a tiny engine would be impractical using other technologies.

INTEGRATED PROPULSION/LIFT/CONTROL SYSTEM FOR AIRCRAFT AND SHIP APPLICATIONS (U.S. PATENT NO. 5,975,462) (M.F. Platzer)

A new method for boundary layer energization and boundary layer propulsion for use on vehicles moving through fluids, which comprises mounting small airfoils parallel or perpendicular to the vehicle's surface, said airfoils being embedded within the said vehicle's boundary layer and juxtaposed the surface of said vehicle, said airfoils being approximately the height of the boundary layer thickness and exciting said airfoils into flapping oscillation parallel to the chord plane of said airfoils, said oscillation at a frequency up to 100 cycles per second at an amplitude up to 20 percent of the chord length of said airfoil, whereby flow separation is delayed or suppressed which enables the redesign of said vehicle.

RESEARCH CHAIRS, *continued from page 26*

RELATIONSHIP RENEWED WITH ARMY TO SUPPORT CHAIR FOR MANPOWER MODELING

The Memorandum of Understanding between the Assistant Deputy Chief of Staff for Personnel (ADCSPER), U.S. Army, and the Naval Postgraduate School, was recently renewed for another year. The agreement was established to provide guidelines for a Chair for Manpower Modeling in the Department of Operations Research at NPS with the Chief, Military Strength Analysis and Forecasting Division, ADCSPER, acting as executive agent.

The objectives of the agreement are to: 1) provide for a liaison between the NPS and the Office of the Deputy Chief of Staff for Personnel, U.S. Army, for civilian and military manpower topics; 2) enable the Chair to provide assistance to the ADCSPER in the application of operations research techniques to civilian and military manpower problems; 3) enhance the education of the U.S. Army students in the Operational Analysis Curriculum at NPS through research and research-related theses; and 4) provide assistance in establishing research projects and theses on manpower-related topics for NPS faculty, U.S. Army students at NPS, and ODCSPER.

Assistant Professor Sam Buttrey of the Department of Operations Research has been selected as the next Chair forManpower Modeling. Professor Buttrey joined NPS in 1996 after receiving his Ph.D. from the University of California at Berkeley. His research and teaching interests are in the areas of classification, general applied statistics, and computer intensive methods of statistics. Professor Buttrey has advised or co-advised over 20 student theses.

CONCEPTS IN LOGISTICS, *continued from page 7*

Sea Based Logistics

Assistant Professor Kevin Gue is working on a project sponsored by the Office of Naval Research that addresses physical distribution problems in Sea Based Logistics, a new methodology being proposed by the Navy and Marine Corps to support the Marine Corps' Operational Maneuver from the Sea (OMFTS) warfighting doctrine. The idea is to support small, highly-mobile forces from the sea, rather than from large, land-based supply points. The sea base acts as a floating warehouse, with MV-22 tilt-rotor aircraft making deliveries to combat units.

The first part of this research produced a distribution planning model that chooses optimal locations for supply units on land and routes material flows through the system in a way that minimizes land-based inventory, also called the logistics footprint. The model is intended to be used by planners to assess feasibility of logistics intentions or to plan material movements in real-time by running the model on a "rolling horizon" basis.

Professor Gue is also looking at warehousing problems on the sea base. He intends to build throughput models and look at storage policies among several ships in the sea base.

FACULTY NEWS

AERONAUTICS AND ASTRONAUTICS

B. Castro, J.A. Ekaterinaris, and M.F. Platzer, "Transonic Flutter Computation for a 2-D Supercritical Wing Inside a Wind Tunnel," AIAA Paper 2000-0984, 38th Aerospace Sciences Meeting, Reno, NV, 10-13 January 2000.

D. Grove, D. Hansen, G. Hobson, and D. Schnorenberg, "Effect of Reynolds Number on Separation Bubbles on Controlled-Diffusion Compressor Blades in Cascade," *Journal of Propulsion and Power* (accepted for publication).

Professor **Oscar Biblarz** and Associate Professor **I. Michael Ross** have been elected to the grade of Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA).

M. Chandrasekhara, "Review of Compressible Dynamic Stall and Its Control," 8th Asian Congress of Fluid Mechanics, Shenzen, China, 6-10 December 1999.

M. Sahin, L. Shankar, M. Chandrasekhara, and C. Tung, "Dynamic Stall Alleviation Using a Deformable Leading Edge Concept -- A Numerical Study," 38th Aerospace Sciences Meeting, Reno, NV, 10-13 January 2000.

K.D. Jones and M.F. Platzer, "Flapping-Wing Propulsion for a Micro Air Vehicle," AIAA Paper 2000-0897, 38th Aerospace Sciences Meeting, Reno, NV, 10-13 January 2000.

J.C.S. Lai and M.F. Platzer, "Jet Characteristics of a Plunging Airfoil," *AIAA Journal*, Vol. 37, No. 12, December 1999.

M.F. Platzer, "Integrated Propulsion/Lift/Control System for Aircraft and Ship Applications," U.S. Patent No. 5,975,462, 2 November 1999.

COMPUTER SCIENCE

R.S. Alexander and N.C. Rowe, "Finding Optimal-Path Maps for Path Planning Across Weighted Regions," *International Journal of Robotics Research*, January 2000.

M. Harn, V. Berzins, and Luqi, "Software Evolution Process Via a Relational Hypergraph Mode," IEEE/IEEJ/JSAI International Conference on Intelligent Transportation Systems, Tokyo, Japan, 5-8 October 1999.

C. Irvine, "Security: Where Testing Fails," The International Test and Evaluation Conference, Atlanta, GA, 22 September 1999.

C. Irvine and T. Levin, "Toward a Taxonomy and Costing Method for Security Services," *Proceedings of the Computer Security Applications Conference*, 8-10 December 1999.

J. McHugh and J.B. Michael, "Secure Group Management in Large Distributed Systems: What is a Group and What Does it Do?" *Proceedings of the New Security Paradigms Workshop*, ACM Press, 1999.

N.C. Rowe, "Precise and Efficient Retrieval of Captioned Images: The MARIE Project," *Library Trends*, Fall 1999.

N.C. Rowe, "Computer Tutor for Logic Semantics," Frontiers in Education Conference (FIE 99), San Juan, Puerto Rico, 10-13 November 1999.

N.C. Rowe, "An Intrusion-Detection Environment for Information-Security Instruction," Frontiers in Education Conference (FIE 99), San Juan, Puerto Rico, 10-13 November 1999.

D. Zhang and Luqi, "Approximate Declarative Semantics for Rule Based Anomalies, Knowledge-Based Systems," 12, 1999.

DEFENSE RESOURCE MANAGEMENT INSTITUTE

R. Abzug and N. Webb, "Relationships Between Nonprofit and For-Profit Organizations: A Stakeholder Perspective," *Nonprofit and Voluntary Sector Quarterly*, Vol. 28, No. 4.

D. Angelis, "Implementing Activity Based Management: A Military Case Study," INFORMS, Cincinnati, OH, May 1999.

J. Felli and G. Hazen, "Do Sensitivity Analyses Really Capture Problem Sensitivity? An Empirical Analysis Based on Information Value," *Risk, Decision and Policy*, Vol. 4, No. 2, 1999.

J. Felli and G. Hazen, "A Bayesian Approach to Sensitivity Analysis," *Health Economics*, Vol. 8, No. 3, 1999.

P.C. Frederiksen and R.E. Looney, "The Effect of Declining Military Influence in Defense Budgets in Latin America," *Armed Forces and Society* (in press).

ELECTRICAL AND COMPUTER ENGINEERING

U. Aktas and R. Hippenstiel, "Localization of GSM Signals Using Wavelet Denoising Based on the Fourth Order Moment," 3rd Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, 24-27 October 1999.

J. Cook, J. Hicks, S. Paxton, and D. Wadsworth, "Military COMSAT Multiplies UHF Channel Capacity for Mobile Users," IEEE MILCOM Conference, Atlantic City, NJ, 1999.

D.J. Fouts, A.S. Lambley, G.K. Lum, G.R. McKerrow, and S.S. Noe, "Second-Layer Polysilicon Structures for Gate End-Around Leakage Current Compensation in Bulk CMOS ICs," *Journal of Microelectronics Reliability* (accepted for publication).

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Polychronos, "Performance Analysis of Non-Coherent BFSK Using First, Second, and Third Order Selection Combining in a Nakagami Fading Channel," MILCOM 99, Atlantic City, NJ, 3-6 October 1999.

R. Janaswamy, "Equivalent Impedance of Rough Surface at Small Grazing Angles," URSI 2000 Meeting, Boulder, CO, 5-8 January 2000.

Prof. R. Janaswamy was elected a member of the U.S. National Committee of International Union of Radio Science (URSI).

T.R. Weatherford, "Low Temperature Grown GaAs Buffers for Rad-Hard Applications," *Proceedings of the 2nd Symposium on Non-Stoichiometric II-V Compounds*, Erlangen, Germany, 4-6 October 1999.

T.R. Weatherford, "Low Temperature (LT) Grown GaAs Buffer Layers for III-V Semiconductor Processes," *IEEE GaAs IC Symposium Technical Digest*, 18 October 1999.

INFORMATION SYSTEMS

B.A. Kitchenham and N.F. Schneidewind, "Towards an Ontology of Maintenance," *Journal of Software Maintenance*, October/November 1999.

J. Munson, A.P. Nikora, and N.F. Schneidewind, "Practical Issues in Estimating Fault Content and Location in Software Systems," *Proceedings of the AIAA Space Technology Conference and Exposition*, Albuquerque, NM, 29-30 September 1999.

A.P. Nikora and N.F. Schneidewind, "Predicting Deviations in Software Quality By Using Relative Critical Value Deviation Metrics," *Proceedings of the 10th International Symposium on Software Reliability Engineering*, Boca Raton, FL, 1-4 November 1999.

A.P. Nikora and N.F. Schneidewind, "Practical Issues in Implementing Software Reliability Measurement," *Proceedings of the 10th International Symposium on Software Reliability Engineering*, Boca Raton, FL, 1-4 November 1999.

N.F. Schneidewind, "Measuring and Evaluating Maintenance Process Using Reliability, Risk, and Test Metrics," *IEEE Transactions on Software Engineering*, Vol. 25, No. 6, November/December 1999.

N.F. Schneidewind, "Can Metrics and Models be Applied Across Multiple Releases or Projects?" *Proceedings of the Sixth International Metrics Symposium*, Boca Raton, FL, 4-6 November 1999.

N.F. Schneidewind, "Investigation of the Risk to Software Reliability of Requirements Changes," 99 NASA Workshop, Morgantown,WV, 28-29 October 1999.

N.F. Schneidewind, "Cost Framework for COTS Evaluation," *Proceedings of COMPSAC 99*, Phoenix, AZ, 27 October 1999.

MATHEMATICS

L. Battha, R. Franke, J. Kalmar, D. Nagy, G. Papp, and J. Zavoti, "Evaluation of Various Gridding Methods," *Acta Geodesy and Geophysics, Hungary*, 1999.

C. Borges and C. Peters, "Computing Approximate Stationary Distributions for Discrete Markov Processes With Banded Infinitesimal Generators," *Journal of Applied Probability*, Vol. 36, No. 4.

R. Franke, "Three-Dimensional Covariance Functions for NOGAPS Data," *Monthly Weather Review*, 127, 1999.

D. Mortari and B. Neta, "K-Vector Range Searching Techniques," 10th AAS/AIAA Space Flight Mechanics Meeting, Clearwater, FL, 23-26 January 2000.

MECHANICAL ENGINEERING

A. Gopinath, "The Role of Viscous Fingering in the Separation Mechanics of Thin Interfacial Liquid Layers," 52nd APS Meeting, New Orleans, LA, November 1999.

A. Gopinath, "Thermoacoustic Streaming on a Cylinder," Symposium on Energy Engineering, Hong Kong, January 2000.

R.E. Robins, D.P. Delisi, and T. Sarpkaya, "Wake-Vortex Eddy-Dissipation Model Predictions Compared with Observations," Aerospace Sciences Meeting, Reno, NV, 10-13 January 2000.

T. Sarpkaya and R. Vaidyanathan, "Spray Generation from Free and Half-Free Jets," Aerospace Sciences Meeting, Reno, NV, 10-13 January 2000.

Prof. T. Sarpkaya has been appointed by the Naval Sea Systems Command to a five-member Advisory Panel for the purpose of examining the technical capabilities of NAVSEA's Submarine Hydrodynamics/ Hydroacoustics Program.

METEOROLOGY

T.S. Bates, S. Businger, B. Heubert, J.E. Johnson, G.L. Kok, P. Krummel, G.L. Kok, D.H. Lenschow, L. Pan, R.D. Schillawski, S. Siems, K. Suhre, and Q. Wang, "Characteristics of the Marine Boundary Layers Observed During Two Lagrangian Measurement Periods, Part I: General Conditions and Mean Characteristics," 1999, *Journal of Geophysics Research*, 104, 21, 751-21, 765.

P.A. Frederickson, K.L. Davidson, C.R. Zeisse, and C.S. Bendall, "Near-Surface Scintillation Over the Ocean," *Propagation and Imaging Through the Atmosphere III, SPIE Proceedings*, Vol. 3763, Denver, CO, 22-23 July 1999.

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C.R. Zeisse, and C.S. Bendall, "Estimating the Refractive Index Structure Parameter (Cn+) Over the Ocean Using Bulk Methods," *Journal of Applied Meteorology* (in press).

P.A. Frederickson, K.L. Davidson, and A.K. Goroch, "2000: Analysis and Validation of an Operational Bulk Surface-Layer (Evaporation Duct) Model," *Program and Abstracts*, National Radio Science Meeting (USNC/URSI), Boulder, CO, 5-8 January 2000.

G.L. Kok, K. Laursen, D.H. Lenschow, L. Pan, L.M. Russell, R.D. Schillawski, K. Suhre, and Q. Wang, "Characteristics of the Marine Boundary Layers Observed During Two Lagrangian Measurement Periods, Part II: Turbulence Structure," 1999, *Journal of Geophysics Research*, 104, 21, 767-21, 784.

H.J. Kwon and R.T. Williams, "Nonlinear Equilibration of Barotropic Waves in a Zonally Non-Uniform Current," 1 January 2000, *Journal of Atmospheric Sciences*, 57, 136-149.

Q. Wang and S. Wang, "Condensation and Evaporation in Turbulence Cloud Parameterizations," 1999, *Journal of Atmospheric Sciences*, 56, 3338-3344.

MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION (MOVES)

Prof. M. Zyda was the plenary speaker at the Third Workshop of the UK's EPSRC (Engineering & Physical Sciences Research Council) Multimedia and Networking Applications Programme in January. Prof. Zyda's presentation was entitled, "NPS MOVES – Entertainment Research Directions." The goal of the workshop was to examine potential research directions in multimedia and networking.

NATIONAL SECURITY AFFAIRS

L.J. Roberts, The Lebanese in Ecuador: *A History of Emerging Leadership*, Westview Press, Boulder, CO, February 2000.

J.J. Wirtz, "QDR 2001: The Navy and the Revolution in Military Affairs," *National Security Studies Quarterly*, Vol. V, Issue 4, Autumn 1999.

J.J. Wirtz, "A Review Essay of H.R. McMaster's Dereliction of Duty," *Political Science Quarterly*, Vol. 114, No 1, Spring 1999.

J.J. Wirtz, "Response to Jonathan B. Tucker, Asymmetric Warfare," *Forum for Applied Research and Public Policy*, Vol. 14, No. 4, Winter 1999.

J. J. Wirtz, "Out on Their Own," Review of Timothy Castle's, *One Day Too Long, International Journal of Intelligence and Counterintelligence*, Vol. 12, No. 4, Winter 1999.

J.J. Wirtz, "A View from Croatia (NATO and Kosovo)," International Studies Association Annual Meeting, Arlington, VA, 11-13 November 1999.

D.S. Yost, "Collective Defense and Collective Security After Kosovo," *NATO After Kosovo*, Bram Boxhoorn, Niklaas Hoekstra, and Rob de Wijk, eds., 1999.

D.S. Yost, "Collective Defense and Collective Security After Kosovo," The Royal Netherlands Military Academy Conference on NATO After Kosovo, Breda, The Netherlands, 16 December 1999.

LT Fabrice Ardhuin (French Navy), a Ph.D. student in Oceanography, received the Outstanding Student Paper Award for the Oceanography Section of the American Geophysical Union 1999 Fall Meeting in San Francisco. The title of his talk was, "Wave Evolution Across the Continental Shelf and Bottom Dissipation: A New Eularian-Lagrangian Wave Model." His dissertation advisor is Associate Professor **Tom Herbers**.

OCEANOGRAPHY

P.C. Chu, N.L. Edmons, and C.W. Fan, "Dynamical Mechanisms for the South China Sea Seasonal Circulation and Thermohaline Variabilities," *Journal of Physical Oceanography, 29, 2971-2989*, 1999.

P.C. Chu, C.W. Fan, and W.T. Liu, "Determination of Sub-Surface Thermal Structure from Sea Surface Temperature," *Journal of Atmospheric and Oceanic Technology*, 1999 (in press).

P.C. Chu and R.F. Li, "South China Sea Isopycnal Surface Circulations," 1999, *Journal of Physical Oceanography* (in press).

D. Koracin, P. Luong, L.N. Ly, and J.D. Paduan, "Response of the Monterey Bay Region to Wind Forcing by an Atmospheric Model," *Proceedings of the Third Conference on Coastal Atmospheric and Oceanic Prediction and Processes*.

D. Koracin, P. Luong, L.N. Ly, and J.D. Paduan, "Response of the Monterey Bay Region to Wind Forcing by an Atmospheric Model," Third Conference on Coastal Atmospheric and Oceanic Prediction and Processes, New Orleans, LA, November 1999.

P. Luong, L.N. Ly, and W. Mastin, "Curvilinear Grid for Fluid Flow and Transport Modeling," 8th International Meshing Roundtable, Lake Tahoe, CA, 13-19 October 1999.

L.N. Ly, "On a True Coupling of Air-Wave-Sea Interaction and the NPS NAM Ocean Model," DoD Workshop

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on Coupling Multi-Physics Problems in Environmental Simulation, Vicksburg, MS, 11-12 January 2000.

J.L. McClean, M.E. Maltrud, J.W. Pelton, and P. Braccio, "1/10-Degree North Atlantic POP," Global Coupled Modeling Conference, San Francisco, CA, 13-15 December 1999.

J.L. McClean, M.E. Maltrud, P. Poulain, and J.W. Pelton, "1/10-Degree North Atlantic POP Forced with NOGAPS Winds," 2000 Ocean Sciences Meeting, San Antonio, TX, 24-28 January 2000.

Prof. J. McClean organized the Office of Naval Research sponsored meeting entitled, "Global Coupled Modeling Conference," in San Francisco, CA, 13-15 December 1999. This meeting brought together researchers from the Naval Research Laboratories (Stennis and West), Los Alamos National Laboratory, National Center for Atmospheric Research, and other universities and laboratories. The goal was to devise a strategy for the development of an ocean/atmosphere/ice coupled system with data assimilative capability for short-term prediction.

OPERATIONS RESEARCH

D.P. Gaver and P.A. Jacobs, "Waiting Times When Service Times are Stable Laws: Tamed and Wild," J.G. Shanthikumar and U. Sumita, Vol. 19, *International Series in Operations Research and Management Science*, Kluwer Academic Publishers, Boston, MA, 1999.

G.E. Hynes and S.M. Sanchez, "Effects of Internet Delivery on Learning Management Communication Skills," Association for Business Communication's 64th Annual Convention, Los Angeles, CA, 1999.

S.M. Sanchez, "ABCs of Output Analysis," *Proceedings of the Winter Simulation Conference*, 1999.

PHYSICS

B. Denardo, J. Earwood, and V. Sazonova, "Experiments with Electrical Resistive Networks," *American Journal of Physics*, Vol. 67, 1999.

SYSTEMS MANAGEMENT

B. Barrios-Choplin and M. McCloskey, "The Effects of Deployment on Army Reservists: A Comparison of Leavers and Stayers," Military Operations Research Society Mini-Symposium on Military Recruiting and Retention, Alexandria, VA, September 1999.

B. Barrios-Choplin, C. Coronado, C. Luby, and B. Starkey, "The Influence of Incentives on Recruiter Motivation," Military Operations Research Society Mini-Symposium on Military Recruiting and Retention, Alexandria, VA, September 1999.

W.R. Bowman and S. Mehay, "Graduate Education and Employee Performance: Evidence from Military Personnel," *Economics of Education Review 18*, 1999.

R. Bradley and N. Roberts, "Research Methodology for New Public Management," International Public Management Network Workshop, Siena, Italy, 28-30 July 1999.

A. Brunning and D. Eaton, "Economic Aircraft Wire Maintenance Inspection and Re-Air-Performance Implications," Third Joint FAA/DoD/NASA Conference on Aging Aircraft, 22 September 1999.

L. Edwards, "Complex Change and Innovation in Healthcare Institutions: A Path for Shaping the Future," 42nd Annual Conference for the American Academy of Medical Administrators (AAMA), Atlanta, GA, 3-4 November 1999.

L. Edwards, "Leadership of Teams in Healthcare: Building Teams for Success," 42nd Annual Conference for the American Academy of Medical Administrators (AAMA), Atlanta, GA, 3-4 November 1999.

Profs. M. Eitelberg and S. Mehay were contributing authors for a DoD Report *Career Progression of Minority and Women Officers*. This is a companion to the Final Report of the 1996 DoD-Wide Equal Opportunity Survey.

K.J. Euske, N. Frause, T. Peck, B. Rosenstiel, and S. Schreck, "Applying Activity-Based Performance Measures to Service Processes: Process Relationship Maps and Process Analysis," *International Journal of Strategic Cost Management*, Summer 1999.

G. Fann-Thomas, "Knowledge Management and Business Communication," Association for Business Communication Conference, Los Angeles, CA, 4 November 1999.

G. Fann-Thomas, "Leadership Development," International Organizational Behavior Teaching Conference, Milan, Italy, 14-17 July 1999.

K.R. Gue, "The Effects of Trailer Scheduling on the Layout of Freight Terminals," *Transportation Science*, Vol. 33, No. 4, November 1999.

G. Hayzak and J. Suchan, "Communication Characteristics of Virtual Teams: A Case Study," Association for Business Communication Conference, Los Angeles, CA, 3-6 November 1999.

G.G. Hildebrandt, "The Military Production Function," *Defense and Peace Economics*, Vol. 10.

L.R. Jones and F. Thompson, "A Model for Implementing New Public Management," *Revista del CLAD Reforma y Democracia 9/15* (in Spanish), October 1999.

M. Kamel, M. Nissen, and K. Sengupta, "Integrated Analysis and Design of Knowledge Systems and

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FEATURED PROJECT

CENTER FOR RECRUITING INNOVATION, *continued from page 3*

Defense for Military Personnel Policy), RADM Barbara McGann,USN, (Commander, Navy Recruiting Command), Dr. Steve Sellman (Director of Accession Policy, OSD), LCDR Dodge, and a number of others as well as Professors Eitelberg and Kamel. As it turned out, OSD lost no time in agreeing to sponsor the research project. The meeting concluded with a firm agreement on sponsorship by OSD and a promise of full cooperation between NPS and CNRC in developing ORS, using the Navy as a test case.

A New Research Center Emerges

For a number of years, Professor Eitelberg and his colleagues hoped to establish a center for conducting military manpower research. In 1995, they had come close to creating a DoD Center for Force Management Studies, which would have been affiliated with the Defense Force Management Analysis Course (or DEFMAC), a short course in military manpower for OSD staffers newly assigned to the Pentagon. Unfortunately, DoD sponsorship of DEFMAC was placed on "indefinite hold" at the last minute because of logistical concerns, and the idea for a center soon evaporated along with its partner course.

The confluence of events described above—along with the exciting opportunity to develop ORS and to explore new approaches to recruiting—revitalized interest in a manpower research center. This time, however, Professor Eitelberg and his colleagues felt that the center should narrow its focus to one key area in sustaining the All-Volunteer Force—namely, recruiting.

The Center for Recruiting Innovation (CRI) was established at NPS as an interdisciplinary, inter-departmental research organization dedicated to studying new approaches toward military recruiting. The scope of research extends to enlisted personnel and officers in all military services, including reserve components. (Currently, CRI researchers are conducting six separate research projects for the DoD and the Navy.) CRI researchers are recognized authorities in a wide variety of fields, drawing upon the unique curricula (such as Manpower Systems Analysis) offered at NPS. Areas of expertise—demonstrated by hundreds of faculty studies, NPS Master's theses, and member publications—include the following: military manpower/personnel policy analysis; military manpower modeling; information technology; force structure and cost analysis; cost-benefit and cost-effectiveness analysis; labor economics; management information systems; military leadership; survey/focus group research; youth propensity for enlistment and advertising effectiveness; recruiting and recruiter incentives; military applicant screening and psychological assessment; military occupational classification and assignment; organizational effectiveness; defense database construction, programming, and management; military diversity management and equal opportunity; military recruiter management; military Delayed Entry Program management; military manpower requirements; military training effectiveness; military personnel attrition; military officer selection and commissioning; and many other related subjects. CRI draws from NPS faculty (adjunct and tenured), graduate students conducting thesis research, and contractor support. CRI's efforts are enhanced by its close association and co-location with the Defense Manpower Data Center and the Defense Security Research Center.

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FACULTY NEWS, *continued from page 33*

Processes," *Information Resources Management Journal 13:1*, 2000.

I. Lewis, "Defense Transportation System," Strategic Intermodal Transportation Course, Kings Point, NY, 20 September 1999.

I. Lewis, "Information-Driven Outsourcing," INFORMS National Meeting, Philadelphia, PA, 8 November 1999.

S. Mehay and R. Pacula, "The Effectiveness of Workplace Drug Prevention Policies: Does 'Zero Tolerance' Work?" *National Bureau of Economic Research (NBER) Working Paper, Series #7383*, October 1999.

M. Nissen, "Procurement Revolution with Intelligent Agent Technology," *PRACTIX*, December 1999.

J. Suchan, "Research Issues in Distributed Learning," Association for Business Communication Conference, Los Angeles, CA, 3-6 November 1999.

CENTER FOR RECRUITING INNOVATION, *continued from page 34*

The Online Recruiting Station (ORS)

The underlying premise for ORS is rooted in three principal points of understanding. First, the key to success during any recruiting year lies in the military's ability to attract young people who may have previously expressed very little or no interest in joining. Further, previous research suggests that an effective way of reaching these young people—as well as those who express an intention of enlisting—lies in Internet technology, which can raise the comfort level of the user and provide greater freedom and control in acquiring information. Finally, all indicators say that access to the Internet among teens is expanding rapidly. In fact, e-commerce researchers project that more than 10 million U.S. teenagers will make a purchase online by the year 2002—up from 2 million teens in 1998 and about 3.9 million teen shoppers in 1999. Added to this is an understanding of the attraction of the Internet for millions of teens who play online games, participate in chat rooms, and gather information for academic assignments. In 1999, 11.1 million teens were described as "active users" of the Web. Conservative estimates are that 15.3 million teens will be active users over the next two years.

The first point—that the military needs to entice young people who may know nothing about the armed forces—comes largely from recruiting research conducted in the 1980s. Each year since 1975, DoD has conducted a Youth Attitude Tracking Study, which provides demographic and attitudinal data on levels of enlistment "propensity" in the nation's youth population. "Propensity" is basically the stated likelihood that a young person will enlist in the military, and it has been a closely monitored measure by recruiting commands and other personnel managers since it was first introduced. The military draws heavily from the population of youth who are strongly attracted to service and are classified as being of "positive propensity"; as many or more than 50 percent of these young people (controlling for qualifying education and aptitude) can be counted upon to actually enlist. At the same time, only about 6 or 7 percent of the so-called "negative propensity" youth may enlist in the military—but, because the vast majority of young people fit into this "negative propensity" category, those who enlist may account for more than half of all new recruits during a given year. Thus, the real challenge of recruiting is to find a way to present the military and its job opportunities to a segment of the youth population that has very little knowledge or understanding, or possibly a negative attitude, concerning "things military."

The initial ORS plan calls for development of "a comprehensive Web site that provides an interactive, multimedia-rich, online community environment for learning about, exploring, and applying for Navy jobs." The site will include three main components: 1) a "Self-Discovery" module that will assist the user in assessing his or her interests and abilities, and then aligning these interests and abilities with compatible Navy jobs; 2) an E-Business module that contains enlistment forms and pre-qualification assessment, presented in an interesting, interactive form; and 3) an Online Community environment that includes a chat room, instant messaging, and other features. All components will be presented in a multimedia format, with state-of-the-art technology. An online game will serve as the central feature of ORS. The game will have elements that allow for assessment of player (or potential applicant) skills; and characters within the game will advance through scenarios by participating in the three components of "Self-Discovery," E-Business (pre-enlistment forms), and Community or team tasks. Additionally, other potential attractions will be offered through the site: viewing selected events (e.g., flight operations on an aircraft carrier; "battle stations" at boot camp; etc.); and selected commands will staff the chat rooms during specified periods of time (allowing young visitors to "talk" with sailors about their jobs).

Initially, ORS will be developed as an advanced, proof-of-concept prototype. A pilot or "beta" system will follow. A production system will be developed and subsequently launched upon completion of testing and evaluation of the ORS pilot.

ORS is considered a "test bed" for possible application on a DoD-wide basis. NPS will coordinate development of ORS with the Directorate for Accession Policy in the Office of the Secretary of Defense, and Commander, Navy Recruiting Command (CNRC). An interdisciplinary team of faculty and students has been assembled to work on the NPS portion of the ORS project, under the NPS Center for Recruiting Innovation. ORS is a multimillion-dollar undertaking that is expected to "revolutionize" the business of military recruiting. Some officials in DoD claim to see the day when the entire recruiting and enlistment process can be handled online. ORS doesn't promise this—yet—but it's a major step toward a future of military recruiting that differs markedly from the past.

MARINE KC130 REQUIREMENTS STUDY, *continued from page 5*

with C as small as 0.1. The C130 wing is sufficiently robust structurally that "failure" means that the aircraft must be grounded, not that an in-flight catastrophe occurs.

The Navy has recently changed the management plan for C130 aircraft. The SLEP/retire decision can be based on the condition of the aircraft, as revealed by inspections, rather than the FLE statistic. This allows the USMC to skip the SLEP and gamble that the onset of WFD will be far enough in the future to justify the avionics modernization. The FLE statistic is still relevant, since it is the best predictor of when WFD will occur. Because the aircraft within each series have different FLEs, it is possible that some aircraft should be retired, while others should not. These facts have motivated us to study the fleet on an aircraft-by-aircraft basis, independently making a theoretical retirement decision for each aircraft.

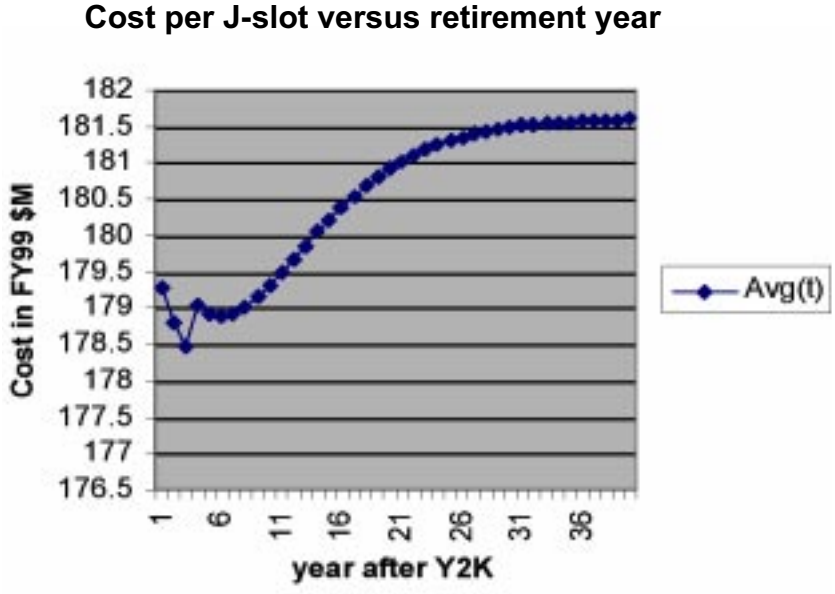

Figure 1. Net Present Value of Infinite-Horizon Costs

For each of the 50 F/R aircraft, our intent is to find the management policy that minimizes the net present value of the cost to provide the services of a KC-130J (fill a J-slot). In all cases the J-slot will be filled in the long run by a KC130J; the only question is whether the slot should be partially filled in the short run by retaining and possibly upgrading a KC130F/R before buying a replacement. Any retained F/R temporarily prevents the purchase of f(t) of a J, where f(t) is the fraction of a J's mission that an F can assume at time t (given relative aircraft availability, mission capabilities and the projected mix of missions, an F/R is currently equivalent to 72% of a J). Present values in 1999 dollars are computed using continuous discounting at 2.9%/year, the current Office of Management and Budget rate for long term calculations.

A probabilistic cost model is used. The model incorporates a random variable for the year in which the first crack appears, where the distribution of the random variable depends on the aircraft's predicted FLE, the associated probability of cracking and the number of independent parts subject to cracking.

Individual Aircraft Considerations: Figure 1 shows the results of the replacement study for a typical aircraft. The economic retirement year is the year T that minimizes the net present value of the cost per J-slot. The results indicate that the typical F/R should be retired just before the avionics upgrade is required (year 3). As Figure 1 makes clear, however, the aircraft should be held until year 6 if for some reason the avionics are upgraded. The cost penalty does not increase strongly during the first decade.

Fleet Considerations: Making all of the assumptions described above, the best decision is to retire all 50 F/R aircraft in about 2003. However, doing so would entail an expense of over $2,000M in 2003. This is not realistic from a fiscal standpoint. Moreover, the KC130J production line and the Marines' training pipeline would both appreciate a more gradual introduction.

The minimal rate at which KC130Js can be acquired without further SLEPs for current aircraft is to replace current aircraft only because of accidents, corrosion, or fatigue cracking. The current fleet effectiveness is equivalent to about 36 J-aircraft. If X of the F/R aircraft are expected to survive at time t, we can calculate the expected number of KC130J aircraft needed at time t to retain fleet effectiveness. Using a fleet simulation model, illustrative results are shown in Figure 2. The dotted lines represent the average number of F/R aircraft remaining and J aircraft purchased. Variance can be indicated by sampling the survival times of all 50 aircraft, and therefore X as a function of time. The results are random, but one replication is shown with solid lines. To keep force effectiveness roughly constant while avoiding SLEPs, it is necessary to acquire about two KC130Js per year; the actual number should await observations about exactly which aircraft are retired at what time.

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MARINE KC130 REQUIREMENTS STUDY, *continued from page 36*

Requirements Analysis

This requirements analysis updates USMC Organic Tanking Requirements (Wu and Alexander, CNA report CRM 96-25, April 1996) and USN/USMC Tanking Requirements (Cox, CNA report CQR 95-19, May 1995). These reports estimated the KC130 tanker requirement to support USMC fixed-wing and rotary aerial refueling demands in two nearly simultaneous major theater wars. KC130 requirements ensured sufficient fuel and an average expected wait of five minutes or less for aerial refueling customers.

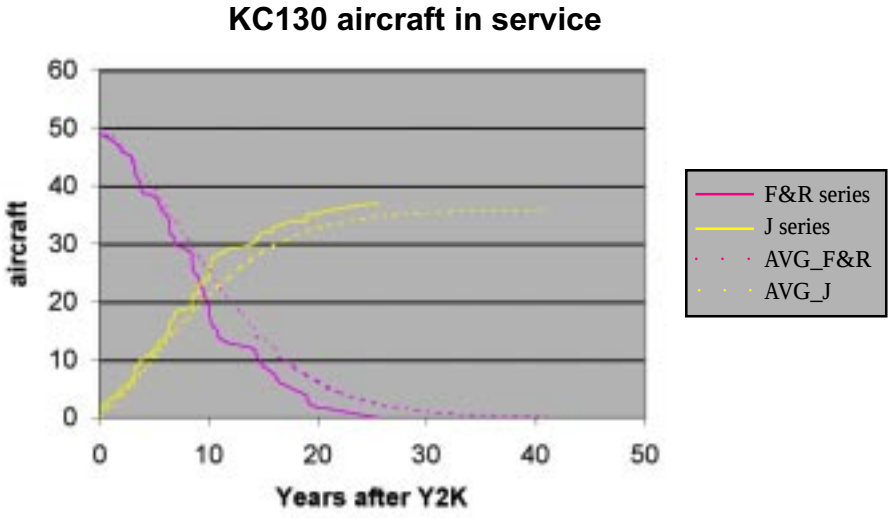

Figure 2. KC130 Fleet Simulation-Stricken KC130F/Rs and Replacement

Aerial refueling is the primary mission, representing as much as 60%-70% of the total KC130 requirement. However, the KC130 can perform other missions, including providing an aerial command post (DASC(A)), cargo delivery, rapid ground refueling and airborne standby. These alternative missions are among those described in the KC130 Tactical Manual and are included in KC130 peacetime training exercises. This analysis will estimate requirements for aerial refueling and these alternative missions.

Base Case Requirements: The KC130J aerial refueling requirement assumes that the USMC retains an organic capability to refuel its F/A-18, EA-6B, AV-8B, MV-22 and CH-53Es. Base case aerial refueling demand assumes CNA customer arrival rates and fuel demands (Cox, 1995). The base case also assumes that 10% of projected MV-22 sorties require aerial refueling. Finally, USMC tankers provided fuel

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UNITED STATES MARINE CORPS (USMC) KC130J TANKER REPLACEMENT REQUIREMENTS AND COST/BENEFIT ANALYSIS

Major Mitchell J. McCarthy, U.S. Marine Corps
Masters of Science in Management - December 1999
Advisors: Associate Professors William Gates and Keebom Kang, Department of Systems Management

NAVAIR funded a research project to answer the question: how many KC130Js Aerial Refueling Tankers will the U.S. Marine Corps (USMC) need to meet their future wartime requirements? This thesis supported that study. Thesis results were incorporated into the recently completed Marine KC130 Requirements Study, by Professors Gates, Kwon, Washburn, and Anderson.

Specifically, the thesis focuses on the tradeoffs the USMC faces between requirements, performance, and life-cycle costs. The KC130J aerial refueling requirement must support expected USMC fixed-wing refueling demand during two nearly simultaneous major theater wars. Furthermore, refueling capacity must keep the average time an aircraft waits in the aerial refueling queue below five minutes. To define the tradeoff between the KC130J requirement and system performance (waiting time), the thesis develops a Simulation Model using the ARENA(c) simulation language. The simulation model highlights the impact of capacity failures (refueling drogues and hoses) and overlaps between KC130J sorties, two potentially significant factors that can't be explored with standard static queuing theory models. Next, the thesis develops a Life Cycle Cost (LCC) Model that incorporates cost variability using the Crystal Ball EXCEL(c) spreadsheet add-on. The model defines the tradeoffs between LCC and KC130J fleet size. The resulting analysis and conclusions specify a base-case KC130J requirement and discuss the tradeoffs between the requirement, life cycle cost and system performance.

MARINE KC130 REQUIREMENTS STUDY, *continued from page 37*

to allied aircraft in previous international coalition efforts. Allied demand is estimated at 10% of organic USMC fixed-wing demand.

In the refueling requirement analysis, queuing theory was used to determine the number of refueling points (hoses and drogues) required on each refueling track. Queuing theory requires three inputs: the average customer arrival rate (e.g., expected customers per minute), average service time (time required to engage the drogue, receive fuel and disengage), and number of servers (hoses and drogues, hereafter referred to as hoses). The queuing model then calculates the average expected wait before customers can begin the service process (approval to engage). This analysis assumed that five minutes is the maximum average acceptable waiting period (as in both CNA reports), and calculated the number of servers required to keep the expected wait below this ceiling. The queuing model assumes random customer arrival rates and service time. The queuing results reflect expected values when the system reaches steady-state equilibrium. However, on-station overlap between KC130J sorties and potential drogue failures may preclude it from reaching steady state.

	Customer Arrival Rate Per Hour	Hoses Required On-Station	Expected Average Wait (Min)	Probability of 4 or More Waiting	KC130J Required	Total KC130J Required
West Fixed	18	2	3.2	10.1%	17.7	
West Rotary	2	1	0.6	0.0%	4.9	
East Fixed	35	4	1.1	6.6%	30.6	59.2
East Rotary	4	1	1.4	0.1%	6.0	
West MV-22	1	1	0.4	0.0%	4.6	
East MV-22	2	1	0.7	0.0%	5.2	69.0

Table 1: Base Case Aerial Refueling Requirements

For example, on-station overlap between KC130J sorties will periodically reduce or eliminate the queue for refueling customers. If the overlap is sufficiently frequent, it may significantly reduce expected waiting time. These issues are addressed in Major McCarthy's thesis.

The theater and platform-specific static queuing refueling results are summarized in Table 1. The KC130J requirement incorporates its 72% mission capability. Thus, this requirement includes allowances for out-of-service and not-mission-capable aircraft, but no allowance for mission capable backup aircraft or training requirements. In the 2-MTW scenario, the West conflict precedes the East conflict. This requirement reflects the peak demand across the two theaters. Thus, the Eastern Theater is reaching its peak while the West is beginning to subside.

Other mission requirements are not specified in the same detail for the 2-MTW scenario as aerial refueling requirements. Therefore, mission requirements are treated as policy variables. Alternative requirements are analyzed using sensitivity analysis. These other missions use KC-130J performance characteristics and mission profiles provided by Marine Aviation and Weapons Tactics Squadron 1 (MAWTS-1).

The base case KC130J requirement is detailed in Table 2. This requirement represents J-equivalent aircraft. It could be partially fulfilled by KC130F/R aircraft.

West		East	
Fixed Wing	17.7	Fixed Wing	30.6
Rotary Wing	4.9	RotaryWing	6.0
MV22	4.6	MV22	5.2
DASC(A)	2.1	DASC(A)	2.1
Cargo	9.5	Cargo	9.5
RGR	3.7	RGR	3.7
Airborne Standby	3.9	Airborne Standby	3.9
Total West	**46.5**	**Total East**	**60.8**
Total KC130J Requirement 107.3			

Table 2. Base Case KC130J Requirements

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MARINE KC130 REQUIREMENTS STUDY, *continued from page 38*

Sensitivity Analysis: The sensitivity analysis examines the impact of alternative specifications for critical KC130J performance and demand assumptions. To illustrate, the total KC130J requirement could be over 200 or as low as 50 with reasonable assumptions reflecting different combinations of high/low KC130J performance and high/low demand for KC130J missions. The requirements for the High/Low Performance-High/Low Demand sensitivity analysis are summarized in Table 3 below.

Conclusions

The findings above together imply a rapid acquisition schedule for KC130J aircraft. In particular, the economic retirement decision is: *Replace the 50 F/R aircraft with 36 J aircraft in about three years, before requirements for flying in European airspace mandate a $2.5M avionics upgrade.*

The USMC has already purchased seven Js that are just entering service. If all 50 of the F/R aircraft could be retired and replaced with 29 additional Js, the resulting fleet of 36 Js would maintain the current KC130 capability. The subsequent acquisition of 71 additional Js would extend it to the capability that we estimate the Marines will need in 2015. It is by no means certain that J aircraft can be purchased at such a high rate, so it may be necessary to retain the F/R aircraft beyond their economic retirement date. Even if F/R aircraft are not deliberately retired, however, minimal purchases of J aircraft will still be required.

Allowing for losses to the F/R fleet due to accidents, corrosion and fatigue, KC130Js must be purchased at the rate of at least two per year to maintain the capability of the current fleet, even assuming that F/R aircraft are not deliberately retired.

It is economically wise but not crucial to retire the F/R aircraft before the required avionics upgrade. Figure 2 shows that the net present value per J-slot is minimized at a 3-year retirement date, but does not increase strongly during the first decade.

A reasonable policy is to acquire KC130J aircraft at a rate that will make it possible to retire most F/R aircraft before about 2010. The requirement for 107 KC130Js by 2015 can be met by acquiring seven new aircraft per year.

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Mission	High Performance/ Low Demand	High Performance/ High Demand	Low Performance/ Low Demand	Low Performance/ High Demand
Fixed-Wing AR	23	38	61	111
Rotary AR	8	8	22	22
MV-22 AR	0	11	0	53
DASC(A)	4	4	4	4
Cargo	7	23	13	38
RGR	2	10	5	23
Airborne Standby	6	6	9	9
Total	**50**	**99**	**113**	**260**

Table 3. High/Low Demand-High/Low Performance Results

ADVANCED ACOUSTICS RESEARCH LABORATORY, *continued from page 9*

volume oscillations, can be modified by the presence of isotropic, homogeneous, broadband acoustic noise when the band overlaps the bubble's resonance width. An important prediction of the theory is that band-limited acoustic noise can *reduce* the drag when the lower frequency of the spectrum coincides with the resonant frequency of the object. For a high intensity band–limited noise spectrum this acoustic drag acts as a discrete separator of particles while they are carried by an external flow. These results may be extended to modify and possibly control bubble migration and heat transfer in two-phase heat flows, where bubbles play a major factor.

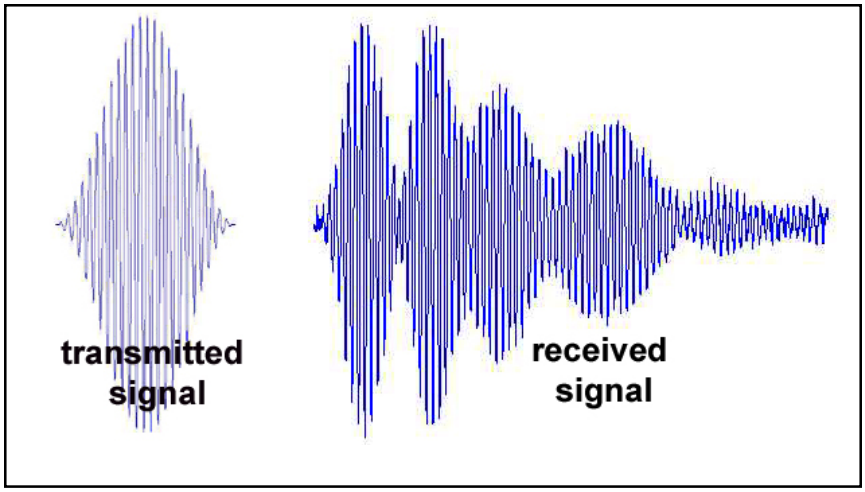

Figure 3. Example of transmitted and received signal in the multipath propagation environment of a rectangular waveguide. The time-scale for both signals is the same.

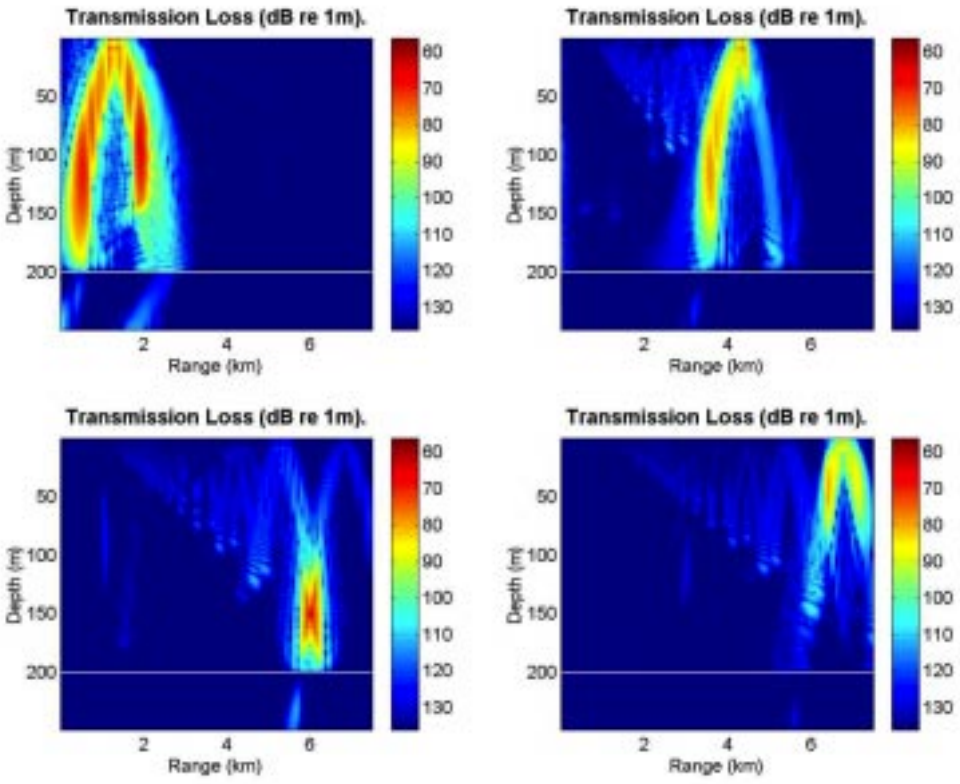

Figure 4. Plots of depth vs. range, at four different times, for the transmission loss of a time-reversed 800 Hz signal transmitted from a full-water-column array. The sound speed profile is that of a surface channel, in a flat bottom topography, with the sea floor at 200 m.

Underwater Acoustic Communications

For underwater acoustic propagation in shallow water environments, a narrow-band pulse generated by a point-like source spreads because of multi-path propagation due to reflections at the surface and at the bottom of the ocean or refractions within the interior. Each propagation path takes a different time, so that the transmitted pulse gives rise to multiple copies, not equally spaced in time, arriving at a receiver (Figure 3). The strong signal degradation due to the multi-path propagation is further enhanced by high spatial and temporal variability of the channel conditions that exist in a typical underwater acoustic channel in shallow water environments.

In a communication link, the signal degradation due to multi-path spreading causes Inter Symbol Interference (ISI) which is the interference between symbols due to multiple arrivals of each transmitted

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symbol. For example, in a shallow water channel with a multi-path spread of 100 ms and 1000 symbols per second, the ISI extends to over 100 symbols. Also, as long propagation times decrease data throughput, available bandwidth is severely limited by transmission loss, which increases both in frequency and in range.

A novel technique called Time-Reversal Acoustics (TRA) can environmentally adapt the acoustic propagation effects of a complex medium in order to focus energy at a particular target range and depth. Additionally, estimates show that TRA focusing can be done at useful ranges (30 km) and over reasonable time scales (30 min) without updating the time-reversed signal under certain conditions. The TRA technique consists of digitizing the analog signal received by a hydrophone, time reversing it, and retransmitting it from a co-located source. If a wide-aperture array of receivers/transmitters is used, the time-reversed signal back at the point-like source is focused in time and space. For a small-aperture array, while the time-reverse signal back at the point-like source does not focus well in space, it still exhibits near-optimal focusing in time.

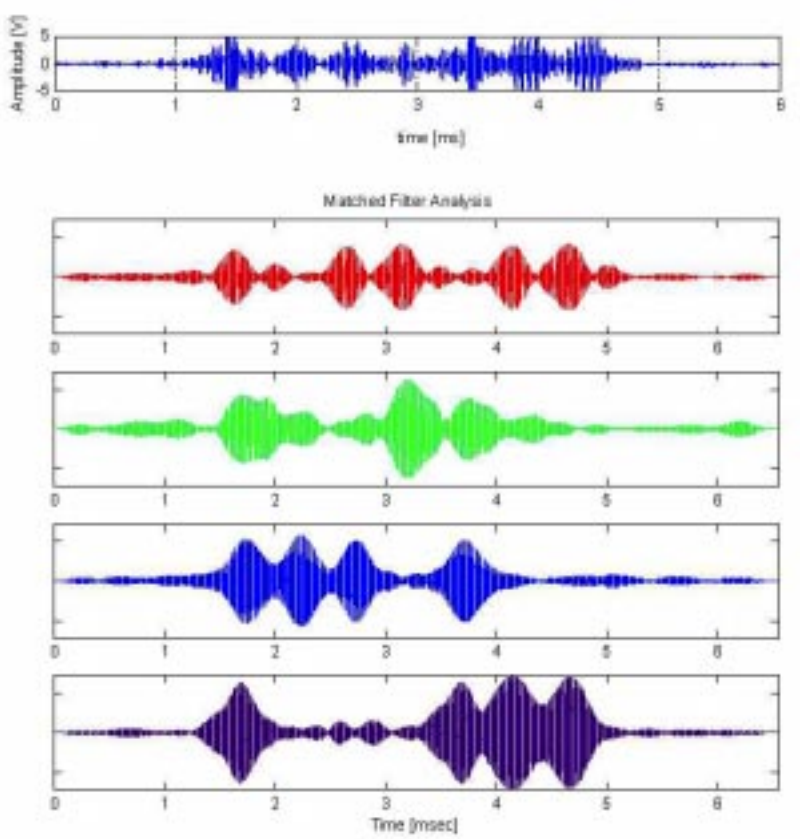

Figure 5. The message is clearly and easily resolvable. The gray lines show the symbols with respect to time. The message reads "DEC 99." For a code contact the authors. Outside the focal region, the message is unclear and not resolvable.

An important step toward useful naval and commercial applications of TRA is to fully explore the capabilities and limits. This exploration is most cost effectively done in tank-scale experiments supplemented with numerical simulations. Part of the function of the AARL is the study of acoustic propagation and its applications through numerical simulation and data analysis. While the data analysis takes advantage of standard signal processing tools, the simulation of the acoustic propagation in underwater environments is often a research effort of its own. The numerical code employed to predict sound transmission in the ocean is the Monterey-Miami Parabolic Equation (MMPE) model. This full-wave model is based on the accurate "wide-angle" parabolic approximation to the Helmholtz wave equation and is implemented via the highly efficient and stable split-step Fourier algorithm. This model was written by Professor Smith, and is now a well-established model in the underwater acoustics community used by numerous researchers around the world. The MMPE model has been at the heart of much of the numerical analyses of research topics within the AARL. The initial studies of TRA at NPS were carried out numerically. In Figure 4, the fundamental character of TRA, the re-focusing at the original source location, is displayed. Calculations of this type helped characterize the focal region and its dependence on environmental parameters.

The properties of time-reversal acoustics suggest a potential application in the field of non-coherent acoustic communications. "Non-coherent" in this sense is meant to imply that no phase information will be transmitted in the communication signal but instead an energy detector method will be used. An algorithm for rapid transmission of binary data in a complex underwater environment was developed numerically, and the results from this work formed the foundation for the thesis by LT Antonio Abrantes (Portuguese Navy, 1999). Figure 5 shows the experimental realization of the algorithm performed in the tank as part of LT Michael Heinemann's thesis. This scheme, for a full transmission bandwidth of 1

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ADVANCED ACOUSTICS RESEARCH LABORATORY, *continued from page 43*

kHz and a pulse bandwidth of 200 Hz, can provide a rate of 2,000 bits/s. This is comparable to current rates with the added benefits of longer range due to energy focusing and covert coding due to the inherent scrambling induced by the environment at points other than the intended receiver. It is expected that more sophisticated signaling schemes can increase this data transfer rate even further.

Environmentally Adaptive Sonar Technologies

Another application of TRA is the sonar work currently developed by CDR Shipley for his Ph. D. dissertation. The goal of this work is to understand how TRA might help enhance active detection or be used as a barrier defense for surface ships against submerged threats. In this case, TRA is used to remove environmental distortions from active sonar signal returns in shallow water using single elements rather than an array. CDR Shipley took this new Navy active sonar approach from first concept to at-sea demonstration in the last year. In the AARL, a complete scaled version of a shallow water active sonar system, was implemented. The results were impressive, with the Time Reversed Acoustic Pulse (TRAP) sonar system demonstrating twice the signal to noise ratio as compared to standard active sonar matched filtered techniques (Figure 6). Numerical modeling of more realistic shallow water ocean environment in support of the TRA active sonar is provided by LT Tom Winter, USN, as part of his thesis work. Both the lab and numerical work were extended to an actual sea test. Through the ONR's LWAD program, CDR Shipley took the laboratory system to sea in September 1999 off the coast of Oregon and employed it against a diesel electric submarine in a real world shallow water environment. Although the analysis of that test is not yet complete, the demonstration of the TRAP sonar system concept in real time at sea was an unqualified success.

Passive Transient Localization, Reverberation in Shallow Water Environments, and General Features of Underwater Acoustic Propagation

Faculty and students associated with AARL have been employing modeling and data analysis techniques to study algorithms for passive transient localization. In this scenario, a distant, submerged target emits a broadband transient transmission, which is subsequently detected by either a surface or subsurface platform. The object of localization is to determine the range and depth of the target based only on this short duration reception. In its current form, the algorithm uses real, measured transient data as input. Perhaps the most significant accomplishment of this work was the successful localization of the transient source with the reception on a *single* hydrophone. New algorithms are now being developed to take the next step by considering optimal ways to combine multiple hydrophone receptions as would be measured on an array with vertical aperture. This will be the thesis work of LCDR Peer Tas, Royal Netherlands Navy.

ONR has now begun a new study of shallow water reverberation in which Professor Smith will employ this combination of simulation and real data analysis to help gain insight into the physical mechanisms which dominate the structure of shallow water reverberation. The initial aspects of this research will provide thesis content for MAJ Lit-Siew Li, Singapore Navy. Finally, advances and improvements to the numerical modeling techniques are continuously being assessed by LT Kirk Weatherly, USN, and LT Yong-Hoon Ha, Korean Navy.

AARL provides a cost-effective resource for basic and applied research, where both industrial and naval applications are pursued. By providing students with innovative and timely thesis topics, AARL supports the educational mission of the NPS.

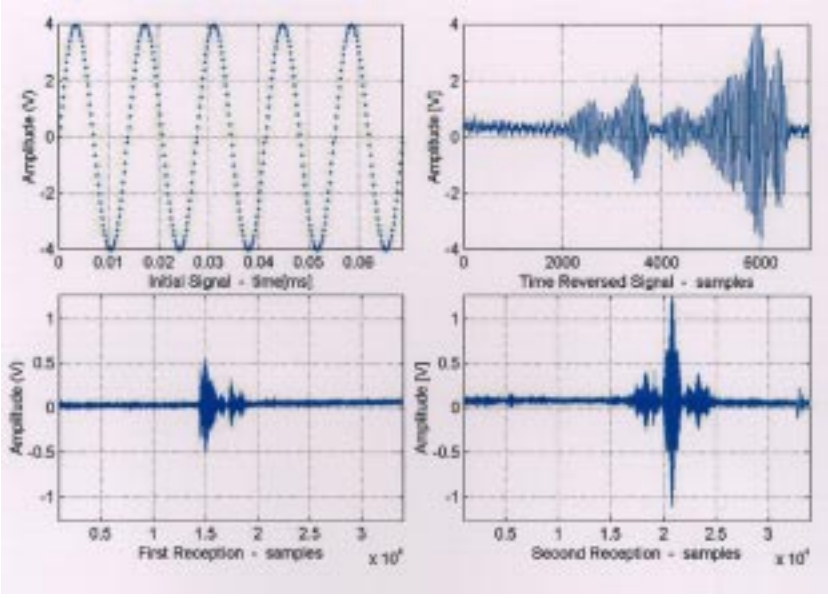

Figure 6. The TRAP solution.

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Date	Title	Sponsor
15-19 Feb 00	10th Defense Advanced Research Projects Agency Symposium on Photonics Systems for Antenna Applications (PSAA-20) (Unclassified)	Defense Advanced Research Projects Agency (DARPA)
28 Feb-3 Mar 00	Classified Advanced Technology Update Short Course (Secret)	NPS
8-18 Mar 00	Fourth International Symposium on Technology and the Mine Problem	NPS
20-24 Mar 00	16th Annual Review of Progress in Applied Computational Electromagnetics (Unclassified)	NPS and Applied Computational Electromagnetics Society (ACES)
27-30 Mar 00	11th Annual U.S. Army Tank-Automotive and Armaments Command Ground Vehicle Survivability Symposium (Secret)	American Defense Preparedness Association (ADPA) and U.S. Army Tank Automotive and Armaments Command (TACOM)
24-28 Apr 00	Technology Review and Update Short Course (Unclassified)	NPS
1-4 May 00	45th Annual Joint Electronic Warfare Conference (Secret)	Naval Air Warfare Center (NAWC)
23-24 Jun 00	35th Annual Colonel Allyn D. Burke Memorial Dental Symposium (Unclassified)	NPS
15-18 Aug 00	2nd International Hypersonic Waverider Symposium (Unclassified)	National Aeronautics and Space Administration (NASA), American Institute of Aeronautics and Astronautics, (AIAA) and NPS
7-9 Nov 00	American Institute of Aeronautics and Astronautics (AIAA) 2000 Missile Sciences Conference (Secret)	American Institute of Aeronautics and Astronautics (AIAA)
19-23 Mar 01	17th Annual Review of Progress in Applied Computational Electromagnetics (Unclassified)	NPS and Applied Computational Electromagnetics Society (ACES)

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